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AN EXPLORATORY STUDY OF COSTS
TO OPERATE GOVERNMENT-OWNED,
CONTRACTOR-OPERATED (GOCO)
FACILITIES

Captain William O. Bennett, USA
Captain Mark L. Hodges, Jr., USA

LSSR 43-81

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During World War II, the U.S. Government recognized a need to expand the nation's industrial base. The government decision was to build production facilities and contract with private firms to operate them. In 1970 the Secretary of Defense issued a directive to sell many government facilities. As of 1980, 147 remained in government possession, being managed differently by each DOD component. The researchers sought to determine if management structure impacted upon operational costs of GOCOs. The researchers discovered that operational cost data were not readily available DOD-wide. A study of Army ammunition GOCOs was conducted to determine if sufficient correlation between costs of operating GOCOs could be found to justify the expense of data collection for hypothesis testing. The results of the study showed positive correlation between operation and maintenance costs of GOCOs and total costs of GOCOs. Production costs were not found to be significantly correlated to operation and maintenance costs. Evidence of a structural variable impacting upon production cost was found. The study recommended further study to refine the cost data, then further research into operational costs and management structure.

LSSR 43-81

AN EXPLORATORY STUDY OF COSTS TO OPERATE GOVERNMENT-OWNED, CONTRACTOR-OPERATED (GOCO) FACILITIES

A Thesis

Presented to the Faculty of the School of Systems and Logistics

of the Air Force Institute of Technology

Air University

In Partial Fulfillment of the Requirements for the

Degree of Master of Science in Logistics Management

By

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June 1981

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This thesis, written by

Captain William O. Bennett

and

Captain Mark L. Hodges, Jr.

has been accepted by the undersigned on behalf of the faculty of the School of Systems and Logistics in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE IN LOGISTICS MANAGEMENT
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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

GLOSSARY

Coefficient of correlation--an index number which measures the degree of association between two numbers. Its sign (+ or -) indicates the direction of corresponding change in the correlation (15:710).

Contracting officer--any person who, either by virtue of his/her position or by appointment in accordance with prescribed regulation, is vested with the authority to enter into and administer contracts, and make determinations and findings with respect thereto, or with any part of such authority. There are three types of contracting officers identified: Principal Contracting Officer (PCO), Administrative Contracting Officer (ACO), and Termination Contracting Officer (TCO) (19:1A-B4).

Correlation--a measure of association between two variables. The variables are said to be correlated when a change in the value of one of the variables tends to be associated with a consistent corresponding change in the value of the other (15:702).

Cost accounting--a display of costs in logical sequence that present a picture to management as to the effectiveness and efficiency of internal operations. Commonly referred to as managerial accounting (10:17).

Cost accounting standards--standards promulgated by the Cost Accounting Standards Board in an attempt to systemize accepted accounting principles by narrowing

the available selection of how contractors identify and record costs, and to require contractor disclosure, where appropriate (10:14).

<u>Cost Accounting Standards Board (CASB)</u>--a five-member board created by Congress to establish cost accounting standards and procedures for accounting for the costs of goods and services provided under contracts negotiated with the federal government (10:799).

<u>Facilities</u>--industrial property (other than material, special tooling, military property, and special test equipment) for production, maintenance, research, development, or test, including real property and rights therein, buildings, structures, improvements, and plant equipment (21:B-102.12).

<u>Facilities contract</u>--a contract under which government facilities are provided to a contractor by the government for use in connection with the performance of a separate contract or contracts for supplies or services. When property other than facilities is provided under a facilities contract, it shall be considered facilities for the purposes of that contract (21: B -102.1).

<u>Generally accepted accounting principles (GAAP)</u>--accounting principles or practices as established by the Financial Accounting Standards Board (FASB) (2:14-15).

<u>Government property</u>--all property owned by or leased to the government or acquired by the government under the terms of a contract. Government property includes both government-furnished property and contractor-acquired property defined as follows:

(i) Government-furnished property is property in the possession of, or acquired directly by, the Government and subsequently delivered or otherwise made available to the contractor;

(ii) Contractor-acquired property is property procured or otherwise provided by the contractor for the performance of a contract, title to which is vested in the Government (21: B-101.6).

Industrial plant equipment (IPE)--that part of plant equipment, with an acquisition cost of $1,000 or more, used for the purpose of cutting, abrading, grinding, shaping, forming, joining, testing, measuring, heating, treating, or otherwise altering the physical, electrical or chemical properties of materials, components or end items, entailed in manufacturing, maintenance, supply, processing, assembly, or research and development operations (21:B-102.12).

Material--government property which may be incorporated into or attached to an end item to be delivered under a contract or which may be consumed in the performance of a contract. It includes, but is not limited to, raw and processed material, parts, components, assemblies, and small tools and supplies (21: B-101.6).

Military property--government-owned personal property designed for military operations. It includes end-items and integral component of military weapons systems, along with the related peculiar support equipment which is not readily available as a commercial item. It does not include government material, special test equipment, special tooling or facilities (21:B-102.1).

Other plant equipment (OPE)--that part of plant equipment, regardless of dollar value, which is used in or in conjunction with the manufacture of components or end items relative to maintenance, supply, processing, assembly or research and development operations, excluding items categorized as IPE (21:B-102.12)

Plant equipment--personal property of a capital nature (consisting of equipment, machine tools, test equipment, furniture, vehicles, and accessory and auxiliary items, but excluding special tooling and special test equipment) used or capable of use in the manufacture of supplies or in the performance of services or for any administrative or general plant purpose (21:B-102.12).

Real property--for purposes of accounting classification, means (i) land and rights therein, (ii) ground improvements, (iii) utility distribution systems, (iv) buildings, and (v) structures. It excludes foundations and other work necessary for the installation of special tooling, special test equipment and plant equipment (21:B-102.12).

CHAPTER I

A PROBLEM OF COST CONTROL

Background

A large percentage of products and equipment required by the Department of Defense (DOD) are unique to that department. These items, such as ammunition, missiles, aircraft and armored vehicles, are not readily marketable or produced in the civilian sector of the United States and the world. Recognition of this fact led the U.S. Government to enter the manufacturing sector of the American economy, just prior to the Second World War (WW II). This involvement was accomplished by the building of government factories and the purchasing of equipment for use in those plants and in the plants of civilian manufacturers who were producing products for the DOD. During WW II, the government's intrusion in the civilian sector continued to grow as the nation and the DOD attempted to meet the wartime requirements of the armed forces of this nation and its allies. The government, in its efforts to assure itself of an adequate industrial base, provided over seventeen billion dollars worth of facilities and industrial plant equipment (IPE) between 1940 and 1944 (22:19).

Since the late 1950s, the demand for the items produced in those plants has been determined mostly by national and international events, and not necessarily by usage. This situation has led to unpredictable demand by which to gauge production. The uniqueness of these products determined that much, if not all, of the IPE in the government's factories is not easily or economically convertible to production of other, nondefense-related items. Private industry, realizing this, for the most part has not been willing to make the large capital investment these facilities required, but has been amenable to operating the plants under contract. By retaining these plants, the government has maintained a portion of the necessary production base from which to expand production during wartime.

These government-owned, contractor-operated (GOCO) plants and the equipment in them are becoming quite old. In 1970 the DOD reemphasized its policy to place maximum reliance on the use of privately-owned facilities in the performance of government contracts. The exemptions from this policy were:

1. non-profit and not-for-profit contractors, and

2. wholly government-owned and contractor-operated plants which do not engage in any competition, whether in bidding or in contract performance, with commercial firms (21:1).

The DOD's efforts to divest itself of the spiraling costs of ownership of the aging plants and machinery were less than successful (11:3). For many of the same reasons that firms were reluctant to make the capital expenditures to build these plants, it seems they are unwilling to purchase them. In the first 14 years of the "sell" program, 61 plants were sold, and 149 remained under government ownership (6:49).

This low rate, 29 percent, of sales would indicate that these GOCOs are not going to be sold rapidly, if at all, under current conditions of the economy and government policy. In the case of the munitions plants it would appear that the DOD will retain them as long as the services have a need for munitions. The business of producing munitions is not considered to be very fashionable nor are the items needed to manufacture munitions readily available to the private sector. Though the age of the plants and equipment make their operation quite costly, the DOD must: (1) prevent duplication of facilities investment, (2) promote cost effective operation of the plants, and (3) keep the plants as ready as possible for use, pending their future sale or other disposition (20:1).

The cost to the government of operation of GOCOs is dependent upon the type and dollar amount of the contract under which the contractor is operating. In order to understand, analyze, or predict the total costs of

operation, it is necessary to divide the total cost into cost elements. The divisions are not always precise due to the nature of the costs themselves, but sufficient accuracy can be obtained for analysis of a particular cost objective; i.e., the function, operation, event, or phenomena about which cost information is desired (1:591). Production contract costs can be divided into three broad categories: (1) manufacturing costs, (2) administrative overhead, and (3) profit for the contractor.

Manufacturing costs are commonly divided into direct materials, direct labor, and manufacturing overhead. Direct materials costs are the costs of the raw materials used in production, and direct labor costs are the costs of labor directly concerned with production. Manufacturing overhead costs are those costs incurred by virtue of the manufacturing process, but which cannot be directly associated with the products manufactured. Examples of manufacturing overhead would be costs to heat or cool the manufacturing plant, costs of insurance on the manufacturing equipment, utilities costs to operate machinery, and labor involved with maintenance and upkeep of production equipment and facilities (2:591).

Administrative costs of overhead can be broadly defined as those costs of operation which are not directly attributable to the manufacturing process. Examples would include costs of clerical personnel, office supplies, and

costs incurred in maintenance of the grounds upon which the plant is situated.

Some, but not all, of the costs which would be grouped into manufacturing overhead and administrative overhead are costs which are incurred by virtue of the age, size, design, and function of the grounds, facilities, and equipment. Maintenance and utilities costs are the most readily identifiable. Those are the costs which the government incurs due to ownership of the facilities and equipment. These costs, plus the capital costs, or value, of the facilities and equipment, are the costs of which the government wished to divest itself.

Literature Review

The Defense Acquisition Regulation (DAR) gives policy and guidance for content and format of contracting for use of GOCOs, but gives very limited guidance for their management (10:vi). The topic of government industrial plant equipment (IPE) was the subject of much research between 1965 and 1980.

However, a bibliographical search of the Defense Logistics Studies Information Exchange (DLSIE) produced only four studies specifically related to facilities (GOCO) contracting management. Mr. Keith A. Ulrich, in his findings on a study of the impact of the phase-out plan for GOCOs, recommended further research into centralization of

control of GOCOs in order to better control their operating costs (19:28).

Lieutenant Colonel Ernest Geipel and Major Mark Dierlam, in a master's thesis completed in 1975, discussed and analyzed opinions of government administrators concerning methods to manage government-furnished property. Their focus was on industrial plant equipment located in the manufacturing facilities owned by contractors. Their findings indicated a lack of control over contract clauses and contracting methods which led to wide divergence in costs. Their recommendations included standardized and enforced control over facilities contract provisions and compliance monitoring (8:78).

Mr. Ulrich produced a study of the management of GOCO plants through contract provisions which, in part, refuted the recommendations for standardization made by Lieutenant Colonel Geipel and Major Dierlam in the area of GOCOs (18:28). Geipel and Dierlam studied industrial plant equipment in Air Force and defense contractors' possession, while Mr. Ulrich studied Army GOCOs. Their findings indicated that the two areas (GOCO versus IPE) should possibly be managed somewhat differently.

No evidence that further studies to that effect were conducted could be found. The studies aforementioned, published between 1971 and 1975, are the most current studies in the area of facilities contracting management.

A search of defense and business periodical bibliographies produced one article concerning the U.S. Government's inability to sell its plants consistent with congressional desires, but it made no observations concerning management policies for control.

Management theory of organization structure is diverse. Research efforts studying effects of different organization structures focus on the variables of communication, decision making, morale, and effectiveness. Organization structure is totally dependent upon the function the organization is designed to perform. All structures share four basic elements. The vertical dimension is the element which defines the levels which compose the organization's hierarchy. The horizontal dimension is the element which defines the divisions, branches, and subsidiaries of the organization. Each level of the vertical dimension can be described in terms of its own horizontal dimension. This definition comprises the third element of the structure which is line and staff functions within the vertical dimension. The fourth element of the structure describes how the line and staff functions within and between the levels of vertical design relate and interact (12:109).

The line function relationships define the flows of authority within the organization. In classic organization structure, a study of the line and staff functions within and between hierarchical levels of the organization

will generally depict the levels to which various decision authorities have been delegated. In essence, all authority rests with the leader in the top level of an organization. In an organization consisting of more than two functions and/or members, authority to make certain decisions which affect the firm as a whole are frequently delegated, or passed down the hierarchical structure to the level at which they can best be made. According to Peter Drucker,

> Decisions should always be made at the lowest possible level and as close to the scene of action as possible. However, a decision should always be made at a level high enough to insure that all activities and objectives affected are fully considered [7:38].

By studying the structure of an organization, decision levels can be inferred by determining the level of hierarchy at which the decision maker must be to either be responsible for all objectives and functions affected by the decision or capable of knowing the impact of the decision on all objectives and functions. The former is relatively easy to determine, but the latter (knowledge of) is often not clear and is the source of the divergent theory on organizational structure. Delegation can and does occur along both line and staff functions. An in-depth study of the organization must be quite detailed to define all line and staff functions and authority delegated. In large organizations, the multitude and complexity of decisions virtually dictates delegation of decision authority. When authority to command and authority for

results are both passed down hierarchical levels, the organization is said to be decentralized (12:199). Under decentralized structures, control of subordinate or lower levels of the structure is maintained by retention of authority to set, monitor, and evaluate policy, procedures, plans, and budgets. The degree of control retained is a function of the degree to which the control measures are broad versus specific (12:205).

Many studies of the effects brought upon an organization by decentralization have been made. The subjects of study have included the impact on total profit, employee morale, the efficiency with which raw materials are converted to products for distribution to users or consumers, and the timeliness and quality of subordinate decisions. Studies have been made of both profit and nonprofit organizations. No study which specifically dealt with the organization structure's impact upon costs could be found.

Selwyn Becker and Duncan Neuhauser studied several theories of organizational effectiveness, among which were those of P. R. Lawrence, J. W. Lorsch, and Jay Galbraith (3:73). Diversity of opinion as to optimal organization structures and empirical evidence to support each theory is the central theme of their book. These studies show one common trait of decentralization, however. Regardless of the control measures adopted by the high levels of the

organization, some control over the impacts of decisions is lost with decentralization.

Robert Albanese defines efficiency as a ratio of output to input. For example, managers are said to be efficient if they produce more and better output with less labor, fewer materials and machine time, and in shorter time. Efficiency implies, more, better, faster, and cheaper (1:13). Anthony and Reece define effectiveness as how well a responsibility center performs its job. Effectiveness is always related to the organization's objectives. Efficiency, per se, is not related to objectives (2:583).

The various studies measure efficiency in terms of profitability or effectiveness in human factor terms. Measures of efficiency tend to be stated in terms of profitability, return on investment, return on sales, or some other measure of dollars output or received versus dollars input. The amounts input are aggregate costs. Changes in the ratio of the value (costs) of inputs and the value of outputs (sales value, or potential value improvement) are a function of many variables such as amounts produced, volume of sales, and overhead costs, which do not distinguish between operational overhead and administrative overhead.

The net effect of this cost treatment is to obscure those costs of operation under differing forms of

organization making differential comparison of costs difficult if not impossible. The costs can be inferred from profit data if sales levels and prices are held constant, since fluctuations in profit would be mostly attributable to changes in costs of goods or services produced (10:29). If a study is made of the magnitude of changes in profit rather than the total amounts of profit, inferences can be made about cost behavior.

It must be noted that cost analysis in a profit-oriented model will include differential effects of supervisory and administrative salaries and costs inherent in different organizational structures. This treatment tends to obscure the differential effects of organization structure on operating costs. Notwithstanding those differential effects, the study of Capuzo and Yanovzas, and others, suggest that operational costs would increase as organizational structure varied from one which is highly centralized with control, policy, and decision authority at the top level, to one which is highly decentralized with more control, policy, and decision authority located at the lowest supervisory level (5:249).

Problem Statement

There existed a need for an objective cost analysis of the operation of government-owned, contractor-operated production facilities to aid in the determination of the

most efficient and effective management of these DOD facilities pending either their disposition or a decision to retain them in government service.

Delimitation

Research Objective

The objective of this research was to conduct a comparison of the costs of operation of GOCOs under centralized and decentralized structures of government management. The costs which were to be compared were costs the government incurs by virtue of ownership of the plants, such as the costs of grounds, plant, equipment, their operation, and their maintenance, which were previously defined and grouped with overhead. The costs would be normalized by square footage of plant area, climate in which the plants are located, and product produced in the plant, as appropriate, so that comparisons could be made. The degree of centralization or decentralization in the management structure was defined as the relative level in the parent DOD component hierarchy at which decision authority rests for the facilities contracting and management decisions, regardless of the level at which authority for management of the commodities produced in the plant rested.

Scope

This research was limited to GOCOs currently engaged in production. Those plants being maintained for

the purpose of future expansion of production were excluded. The costs of GOCO operation did not include the costs of U.S. Government employees engaged in their management. This approach allowed the operational costs under the various structures to be studied without the biased inclusions of the total cost of the structure itself.

Research Hypothesis

The results of this research would be used to test the research hypothesis:

The normalized cost of operation of government-owned, contractor-operated facilities under centralized control is less than the normalized cost of operation under decentralized control.

Decision Rules

The decision rules are stated as questions with which to test the hypothesis:

1. Does a correlation exist between normalized cost of operation of GOCOs under centralized control versus those under decentralized control?

2. If so, is this correlation affected by the degree or level of centralization versus decentralization?

3. If so, is the normalized cost of operation significantly reduced as the degree of centralization is increased?

CHAPTER II

METHODOLOGY

This chapter describes the population to be studied and sampling techniques to be employed; presents the data collection plan; and describes the statistical tests which will be used to evaluate the findings.

Population and Sample

Description

The population to be studied consisted of all government-owned, contractor-operated (GOCO) plants in operation, excluding those being held dormant for expansion capabilities during times of national emergency.

In order to accomplish the research objective, the population was divided into two subpopulations, one consisting of GOCOs managed under a centralized form of control and the other consisting of GOCOs managed under a decentralized form of control. The proportion of GOCOs in each subpopulation was to be determined from a random sample of all GOCOs. Statistics computed from the sample would be used to estimate the parameters of each subpopulation group.

Data Collection

At the time of this research, one hundred forty-nine (149) GOCOs were in operation in the continental United States (6:49). They are managed by the federal agencies utilizing the individual products manufactured in each. The data which determined the independent variables were the relative degrees of centralization versus decentralization found in the federal agencies' management control system. The data which comprised the dependent variables were contained in the records of the individual GOCOs or their managerial first level of supervision.

Independent Variables

To obtain information concerning GOCOs, an informational (fact) questionnaire would be sent to each GOCO in the sample as described below. The questionnaire would seek to determine five attributes of the management hierarchy over each GOCO:

1. What organizational unit (office) within the hierarchy manages production contracts in the GOCO?

2. What office manages facilities contracts for GOCOs?

3. What office makes facilities contracts policy?

4. What office negotiates production and facilities contracts?

5. Where in the organizational hierarchy is each of the above offices located?

Actual subpopulation membership criteria would be determined by observations of the sample data. The initial answers would be scaled between the level of the office making facilities contracting policy and the office negotiating facilities contracts. If these offices were the same, complete centralization would be said to exist. If not the same, the increasing number of offices (hierarchical levels) between them would measure degrees of decentralization.

Dependent Variables

The dependent variables in this study were the costs which commonly are allocated to production costs in the form of manufacturing overhead (10:107-133). Eight costs would be considered:

1. Building maintenance costs--these are costs of routine repair and maintenance to the buildings which house the GOCO. They would be normalized by the researchers for study by stating them in dollars per square foot of plant area ($/sq ft).

2-4. Utilities--heat, power, and water. Heat and power would be separated if different energy sources are utilized. Analysis would be both combined and separate to allow for differences in power consumption for different

manufacturing processes. These costs would be normalized as $/sq ft as in building maintenance costs.

5. Machine maintenance--costs to effect minor repairs and routine maintenance to machinery used in production. Machine maintenance would be normalized in dollars per operating hour of machinery ($/op hr).

6. Grounds--costs to maintain the grounds surrounding the plant. Included would be costs of roadway maintenance. These costs would be normalized as dollars per acre ($/acre).

7. Administrative costs--costs of administration which are allocable to the production process. They would be normalized as dollars per dollar of the contract ($/$contract).

8. Security costs--these are costs to secure the plant and grounds both during and after normal business hours. They would consist of only those costs reimbursed to the contractor, and would be normalized as dollars per hour of security labor ($/hr).

These costs were thought to be located in records of individual GOCOs in documents which were prepared incident to production contract and facilities contract administration. Their particular location was thought to be dependent upon the specific provisions of the facilities contracts.

Sample Size

The foremost consideration in determining sample size for this study was to insure that the sample proportions of subpopulations were representative of the population proportions. Therefore, the formula chosen to determine sample size was one which emphasizes those parameters as follows (8:162-165):

$$s_p = \sqrt{\frac{N-n}{N-1} \cdot \frac{p(1-p)}{n}}$$

The formula was evaluated using the following criteria:

s_p = the standard error of the population proportion estimated by the sample (8:163), given by

$$s_p = \sqrt{\frac{p(1-p)}{n}} \quad (8:156).$$

$p(1-p)$ = variance of the sample observations, when set over the sample size n. It is a measure of the sample dispersion (8:156). When nothing is known about the population proportions, p is set equal to .5, which maximizes the expression $p(1-p)$. This produces the maximum sample size consistent with other parameters. p can be either proportion of a dichotomous population as $p+(1-p)=1$. The population studied was considered dichotomous in the sense that management control is either centralized or not.

$\frac{N-n}{N-1}$ = finite correction factor applied to the variance estimate to correct the estimate S_p^2 when the sample exceeds 5 percent of the population (8:163). n = sample size (to be determined) and N = population size, which for this study was 149.

$1.96s_p$ = 95 percent confidence level for the estimate or the interval within which the population proportion lies (8:163). This involves an assumption that the sample size will be large

enough to estimate the binomial probability distribution, which is symmetrical at p=.5, with the normal probability distribution. $1.96s_p$ is an estimate of 1.96 standard deviations (errors) above and below the sample mean proportion, an interval within which 95 percent of all the sample observations for p are expected to fall (8:156). This confidence level was arbitrarily picked by the researchers.

± 0.10 = difference between the proportions estimated by the sample and the actual population proportion, called the sampling error (6:163). This level was arbitrarily picked by the researchers. Since we desired $p \pm 1.96 s_p = p \pm 0.10$, $s_p = \frac{.10}{1.96} = .051$.

Using the data given above,

$$s_p = \sqrt{\frac{p(1-p)}{n} \cdot \frac{N-n}{N-1}} = .051 = \sqrt{\frac{.5(1-.5)}{n} \cdot \frac{149-n}{149-1}}$$

$$n = 58.638 \simeq \underline{\underline{59}}.$$

In order to obtain the sample of 59, a list of all GOCOs was to be compiled and given a unique reference number. A random number table would be entered at random and used to select 59 reference numbers, whose matching GOCOs would comprise the sample.

Each GOCO selected would be sent a questionnaire, as explained earlier, and a letter explaining the research, requesting assistance with the research, and requesting the aforementioned cost data for the past three years. Only three years' data would be utilized to minimize the workload for the GOCOs responsible and to reduce the erratic

impact of OPEC oil price increases on energy costs between 1974 and 1978.

Analysis Evaluation

Data Analysis Technique

The data would be analyzed using the routines available in the Statistical Package for the Social Sciences (SPSS). Task-name FREQUENCIES (14:182) and CROSSTABS (14:218) would be used to evaluate the questionnaires and form the subpopulation proportion estimates. The sample distributions of each cost-type would be evaluated for normality with the task-name K-S (normal), one of the NPAR test subroutines (11:73). This is one version of the Kolmogorov-Smirnov goodness of fit test. It was expected that the data, possibly transformed, would have a normal distribution or not depart too markedly from normal. This would allow parametric tests to be conducted to test the research hypotheses. If the normality assumption was not satisfied, other tests in SPSS subroutine NPAR would provide nonparametric tools to evaluate the variables under study. All possible contingencies are not discussed here, proceeding rather with a description of testing using parametric procedures.

Testing the Research Hypothesis

The research hypothesis was restated as follows:

The normalized cost of operation of government-owned, contractor-operated facilities (GOCO) under centralized control is less than the normalized cost of operation under decentralized control. The hypothesis would be tested by way of test results of the three operational decision rules, restated here along with proposed test and decision rules:

1. H_0: No correlation exists between the normalized costs of operation of GOCOs under centralized versus decentralized control.

   H_1: Normalized costs of operation are statistically related to type of control.

CROSSTABS procedure of SPSS would be used to test the relationship between costs in each subpopulation, and we would reject the null hypothesis if the computed chi-square value exceeds the preselected critical value of chi-square at the arbitrarily selected significance level of .05. This means that the observed sample relationship is so rare, assuming no relationship exists in the population, as to only occur with a probability of 0.050 or 5 percent of the time if a large number of samples were taken. SPSS prints significance (probability) values so that consultation of probability tables was unnecessary (14:223-224).

2. H_0: The mean normalized cost of operations in GOCOs managed by centralized control = the mean normalized cost of operations in GOCOs managed by decentralized control.

H_1: The mean costs under decentralized control > mean costs under centralized control.

SPSS t-test procedure would be used for each category of cost to determine which cost types are consistent with the null hypothesis and which with the alternate hypothesis. The decision rule was to reject the null hypothesis if the computed t* statistic exceeds the arbitrarily selected critical value of student's t statistic at the .05 significance level (14:271).

3. H_0: The normalized cost of operation of GOCOs is not statistically significantly affected by the degree of centralization of managerial control.

   H_1: The normalized cost of operation of GOCOs is inversely related to the degree of centralization in managerial control.

The ANOVA subroutines of SPSS offer different tests of significant variance. The appropriate test would be determined by results of previous tests and the configuration of the data.

If the null hypothesis was rejected in all three decision rules, there would exist sufficient statistical basis to conclude that the research hypothesis is valid. If the null hypothesis was rejected in some, but not all decision rules, the results would possibly be inconclusive and necessitate further research.

CHAPTER III

REDEFINING THE RESEARCH PROBLEM

Introduction

As the researchers began to implement the sampling plan, they queried the individual commands having responsibility for the GOCOs selected for this study. The researchers felt it necessary to insure that the accounting forms and categories of cost desired would be understood by the recipients of the request for data, since some variation in terms and definitions is common in financial and cost accounting (2:12). They discovered that the data desired was not available in the format desired. This chapter describes the nature in which the data was found to be kept, the possibilities for study of the data available, and the revision of the research questions.

The Nature of the Data

A query of the Air Force plants chosen for the sample revealed that operating costs as defined for this research, are treated as items accumulated in the contractor's overhead pools. Under contracts for GOCO facilities which contain lease provisions, such costs become purely those of the contractor and thus are accounted for in accordance with the accounting methods negotiated in the

production contract. Cost summaries maintained in government files for those plants do not distinguish the overhead items specifically, as they reveal allocations of overhead pools only. The actual accounting data, while available to the administrative contract officer (ACO), are considered proprietary and not immediately available for external research. Collection would be possible by traveling to each plant, but even then collection was uncertain due to contractor discretion to account for those costs within the Cost Accounting Standards Board (CASB) options under which he was required to operate.

An example of how the costs would be unavailable under such lease provisions would be a contractor's accounting for equipment maintenance. It would be normal and within generally accepted accounting principles (GAAP) for the contractor to account for routine maintenance in terms of standard or variable labor hours, without differentiating between government equipment by type, and (possibly) his own equipment. He could then allocate the cost of materials used for this maintenance in a similar method. Thus, the total costs which the government must pay have been accounted for, but any distinction as to distribution of those costs between government and contractor facilities is lost.

Accounting for operating costs under Air Force GOCO contracts which do not contain lease provisions was found

to be different, but not appreciably so. In those instances, the overhead pools are accumulated and allocated so as to be accountable under the appropriate government fund source with which they are to be paid. Cumulative amounts by fund source are maintained, but those accounts do not necessarily differentiate costs in the detail needed for this research. A query of Navy GOCO plants revealed similar situations with identical implications. That is, the detailed data necessary to test the research hypothesis in Chapter I could realistically be obtained only by visual search of contractor accounting documents located at those particular GOCO plants under study.

A query of Army GOCOs under the U.S. Army Armanent Material Readiness Command (ARRCOM) revealed that they maintained data on a monthly report, DA Form 4812-R, for each GOCO. This form was prepared by the contractor at each GOCO and submitted to ARRCOM. The forms provide cost data by fund source and individual accounting item. A sample form is shown at Figure 3-1. In describing the formats, according to HQ ARRCOM, the fund source operation and maintenance accounts (OMA), include some production work which involved refitting and rework of outdated lots of ammunition and various modifications to include improvements of existing ammunition. However, the researchers were

ITEM	FUNDING SOURCE						TOTAL
	PRODUCTION		NONPRODUCTION		OMA		
	DIRECT a	INDIRECT b	DIRECT c	INDIRECT d	DIRECT e	INDIRECT f	h
DIRECT MATERIAL	55,558.15		12,876.06		56,798.73		125,232.
OTHER DIRECT COST							
DIRECT LABOR	221,416.28		11,187.33		84,979.89		317,583.
FRINGE BENEFITS	98,264.55		4,964.94		37,714.07		140,943.
DIRECT LABOR HOURS	40,564.0		3,877.0		11,446.9		55,887.
FOR COST CENTER OVERHEAD	201,415.81						201,415.
PRODUCTION SUPPORT	3,335.94	30,915.43					34,251.
UTILITIES	5,445.55	44,684.77		4,118.14		10,703.20	64,951.
MAINTENANCE	26,904.64						26,904.
MATERIAL MANAGEMENT	17,375.82	97,921.51		12,122.56	5,386.52	23,454.86	156,261.
ENGINEERING	9,478.29	18,832.71	58,558.64	2,490.72	18,652.24	4,510.94	112,523.
FACILITIES		127,831.90		16,612.23		30,619.21	175,063.
GENERAL AND ADMINISTRATIV		101,195.16		12,080.81		24,238.97	137,514.
TOTAL OVERHEAD	263,956.05	421,381.48	58,558.64	47,424.46	24,038.76	93,527.18	908,886.
FUNDED INVENTORY							
CAPITAL ASSETS							
FEE	37,875.00						37,875.
TOTAL CONTRACTOR COSTS	677,070.03	422,186.94	87,586.97	54,493.56	203,531.45	95,394.29	1,540,263.
GOVT FURNISHED MATERIALS	6,347,020.93		536.17		701.36		6,348,258.
TOTAL COST	7,024,090.96	422,186.94	88,123.14	54,493.56	204,232.81	95,394.29	7,888,521.
Miscellaneous Costs							
Included in CP Total		805.46		7,069.10		1,867.11	9,741.

Fig. 3-1. Extract of Army Cost Data

informed that all of the costs under study were contained in the operation and maintenance accounts.

Hypothesis Dilemma

Two points critical to the research in question were now apparent. First, the nature of accounting for the costs under study would make statistically valid random sampling by mailed request difficult, if not impossible, as the non-response rate would be due in large part to the nature of data accumulation and not to random chance. This could skew the sample in an unpredictable manner, possibly rendering it unsuitable for statistical inference. Second, collection of data would involve extensive travel to the various contractors' plants and possibly require payment to the contractors for additional accounting efforts not originally contracted for by the government. Either method of collection would have involved a considerable expenditure of funds and time not available to the researchers. The sample data received from ARRCOM consisted of input from seven of the twelve ARRCOM GOCOs currently in operation. The data were also stratified as to contract type: Cost Plus Fixed Fee (three each); Cost Plus Incentive Fee (two each); and Cost Plus Award Fee (two each). All costs under study were contained in an identifiable source arrangement by cost categories in accordance with generally accepted accounting principles.

Redefinition of Objectives

The arrangement of cost data would allow a study to determine if operational costs of GOCOs were correlated in a statistically significant sense to total contract costs, and if such costs were statistically affected by some other structural variable.

The researchers reasoned that if a study of available data found significant correlation between operational and maintenance costs, and total costs, further research might be warranted. Furthermore, if significant correlation was found, the nature of its impact and possible prediction of causal relationships might be identified. If no significant correlations could be found, actions taken by government and contractor management, to lower or control the increase of O&M costs, could have unpredictable effects on other costs, including totals. In such a case, the actions taken could have the effect of merely reducing O&M costs with no statistical probability of reducing total costs or long run costs of ownership.

Conversations with representatives of the ARRCOM GOCOs revealed that, in general, OMA expenditures were predominantly of the type previously defined as operational costs of GOCOs, only infrequently containing other expenditures. Their descriptions of OMA costs led the researchers to conclude that the makeup of OMA cost data was pure enough for this research. The researchers also felt that

they could conclude that no correlation existed between operational costs and other costs provided no correlation of OMA was found, and that reasonable chances of those factors being correlated would exist if significant correlation between OMA and other cost elements was found.

In addition to an analysis of correlation and other additive effects among OMA costs and other cost elements, the researchers desired to search for some structural-type impacts on the cost elements involved. It was reasoned that if some structural interaction could be found with any of the cost elements comprising total contractor costs, further study for structural effects on operational costs might be warranted. The original structural dimension of management organization could not be studied since all data were from the same organization. Noting that the GOCOs sampled were grouped by type of contractual instrument, the feasibility of using contract type as a surrogate structural variable was explored. It was reasoned that if the contractual arrangements differed enough to imply varying managerial structures for contract management and cost control, then the type of contractual arrangement could act as an indicator of structural impact upon the different cost elements of total cost.

Background

Cost Reimbursement Contracts

The use of cost reimbursement contracts, especially cost plus fixed fee contracts, increased steadily in the 1950s. It occurred as a matter of need as the level of technology continued to expand, and the need to keep abreast of these changes became necessary. With rapid change came risk, and it was necessary for the government to defray cost risks by offering cost type contracts to the contractors.

The simplest form of cost reimbursement type of contract is the cost contract. Under this form of contract, the government agrees to reimburse the contractor for all allowable costs but provides no fee or profit. This type of contract is used primarily for research and development work at educational and nonprofit organizations (4:129).

Cost Plus Fixed Fee Contract

The Cost Plus Fixed Fee (CPFF) contract provides for reimbursement of all allowable costs involved in completion of the contract. In addition, the government pays the contractor a fixed fee, which is negotiated, based upon estimated costs. CPFF contracts are often criticized as being open to abuse and inefficient in controlling costs. They represent approximately 12 percent of all contracts awarded. CPFF contracts are also used for research

and development, when scope of work cannot be definitely described or the cost accurately estimated, when completion of the project is in doubt, and when specifications are incomplete. In a CPFF contract, all of the cost risk is assumed by the government (4:130-131).

Cost Plus Incentive Fee Contract

Under a Cost Plus Incentive Fee (CPIF) contract, the contractor is reimbursed for all allowable costs incurred in the performance of the effort. In addition, the contractor is paid a fee, the amount of which is contingent upon the contractor's ability to control costs. Normally a minimum and a maximum fee are negotiated, with the minimum fee designed to prevent the contractor from suffering any out-of-pocket losses. The maximum fee is designed to motivate the contractor to reduce costs. The fulcrum for the entire incentive concept is the target cost. The contractor can increase his level of fee by keeping cost below the target cost. The level of additional fee is predetermined during the contract negotiations and is defined by the share formula.

The share formula represents the agreement between the government and the contractor as to the amount of each dollar of savings or cost under or over the target cost that each party will share as fee or cost. The share formula is designated as a ratio. For example, the share

ratio could be designated as 85/15 with the former (85) being the government's share and the latter (15) being the contractor's share. Table 3-1 is an example of a CPIF arrangement. In the example, the incentive would be effective over a range of $7,000,000, an underrun of 40 percent and an overrun of 30 percent. The contractor's share of a $4,000,000 underrun would be 15 percent or $600,000: his share of $3,000,000 overrun would be 15 percent or $450,000. Added to or subtracted from this target fee of $750,000, the share could result in a fee at the maximum level of $1,350,000 and at the minimum level of $300,000. Notwithstanding the fact that the actual variation from target costs may be greater than plus $3 million or minus $4 million, the effect of the incentive arrangement under the example would be to fix the fee at either the maximum or minimum levels.

Cost Plus Award Fee Contract

The Cost Plus Award Fee contract, a variation of the Cost Plus Incentive Fee contract, was introduced in the mid-1960s for use in the acquisition of maintenance, operations and other service-type activities. The DAR allows the use of the award fee provision when contractor performance is in part subjective. It provides a means of applying rewards in contracts which do not lend themselves to

TABLE 3-1

EXAMPLE CPIF ARRANGEMENT (19:2C17)

Target cost	$10,000,000
Target fee	750,000
Maximum fee	1,350,000
Minimum fee	300,000
Share formula	85/15

Using the example, assume final cost is $9,000,000:

Target cost	$10,000,000
Final cost	-9,000,000
Difference	$ 1,000,000

The contractor receives 15 percent or $150,000 of the $1,000,000 difference between target and final cost as an increase in fee:

Target fee	$ 750,000
Share	+150,000
Final Fee	$ 900,000

The government receives 85 percent or $850,000 of the $1,000,000 difference between target and final cost as a reduction in price:

Final cost	$ 9,000,000
Final fee	+900,000
Final cost plus fee	$ 9,900,000
Target cost plus fee	10,750,000
Reduction in price	$ 850,000

finite measurements of performance necessary for implementing and structuring incentive contracts (4:133).

The fee established in a CPAF contract consists of two parts: (1) a fixed base amount which does not vary with performance, and (2) an award fee amount which is designed to spur the contractor to levels of performance above minimum acceptable standards (23:3-6).

The award fee is a unilateral decision made by the government and is not subject to the disputes clause of the contract. In the negotiation of the contract, the government and the contractor agree upon what is to be measured, frequency of evaluation, and the criteria being applied. The criteria generally measure the elements of performance most significant to the government such as control of direct and indirect costs, betterment of delivery schedule, quality of work, or management effectiveness. The government's periodic evaluations of these elements establish the amount of award fee the contractor receives.

Definition of Structural Variable

Management of a CPFF contract arrangement by a government agency entails, in addition to production, quality, and schedule performance, broad monitoring of a contractor's performance in all cost categories in order to attempt to minimize total cost. Management of CPIF and

CPAF contracts require close monitoring of cost categories not incentivized by the contract to be controlled or reduced by the contractor. The extent to which monitoring would be necessary would depend upon how many and which cost elements or categories were incentivized for contractor control. Monitoring the three types of contracts would require differing managerial actions, organizations, or both. The term organization refers to the size and functions of the staff required for monitoring costs, and the extent to which different personnel or staff elements perform like tasks.

No attempt has been made to ascertain the precise management organization administering each contract, or to group them by management categories. Differences in the contract types imply differences in management organizations and functions in the administration and execution of those contracts. With the use of a surrogate structural variable, if significant relationships could be found between cost elements and contract types, structural impacts on cost behavior in GOCO operations could be inferred.

Revised Research Questions

The research effort was redirected toward a search for relationships which would indicate whether or not expenditure of funds was warranted for further study of the

original hypothesis. To control the search for existing relationships to those applicable to this research, the study was organized to answer two primary research questions, each with supplemental questions:

1. Do any statistically significant correlations exist between the cost elements which comprise total contractor costs in operation of GOCOs?

a. If so, are operation and maintenance costs among those with significant correlation?

b. If so, do the effects of operation and maintenance costs upon total cost change significantly when all other cost effects are controlled?

2. Do any significant changes occur among the correlation coefficients between the cost elements which comprise total contractor costs in operation of GOCOs when the elements are separated into groups by type of contractual arrangement?

a. If so, are operation and maintenance costs among those with a significant change in correlation?

b. If so, do the effects of operation and maintenance costs upon total cost change significantly when the other cost effects are controlled?

c. If so, does this significance differ by type of contractual arrangement?

The answer to these questions would provide an improved framework against which to make an objective

decision whether to undertake the costs of further research aimed at defining the relationships between operational costs of GOCOs and management control structure. This result now became the research objective. The methodology and decision criterion diagram for the conduct of the study are presented in the next chapter.

CHAPTER IV

REORGANIZATION FOR EXPLORATORY RESEARCH

Introduction

The researchers devised a plan to analyze the data available for evidence of correlation between operations and maintenance costs of GOCOs and their total costs. This chapter depicts the process of analysis by decision levels. Each decision level contains the statistical tests to be performed, and their rationale. The decision criteria for answering each question are given at the appropriate decision level.

Development of the Research Plan

In order to systematically search the data base available for answers to the research questions and their supplemental questions, and to avoid introducing statistical bias into the results, a decision flow process chart shown in Figure 4-1 was constructed. At each level, the statistical procedure used and specified alpha level of decision risk to be employed is displayed. These were determined in advance to avoid introducing bias during the course of the study and thereby avoid unwarranted findings. The relatively high levels of alpha risk reflect the desire to give any statistically significant relationship

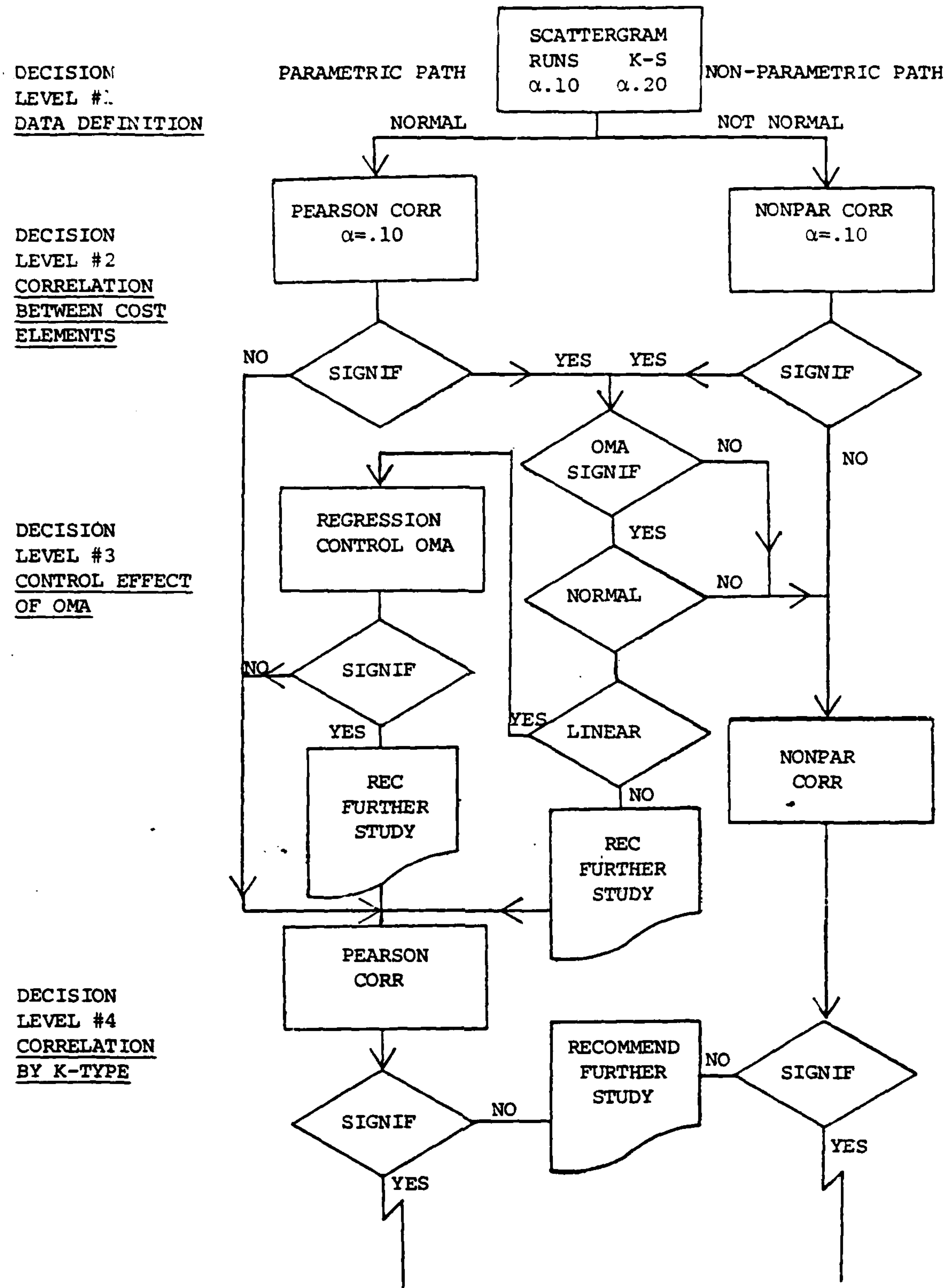


Fig. 4-1. Research Design Flow Chart

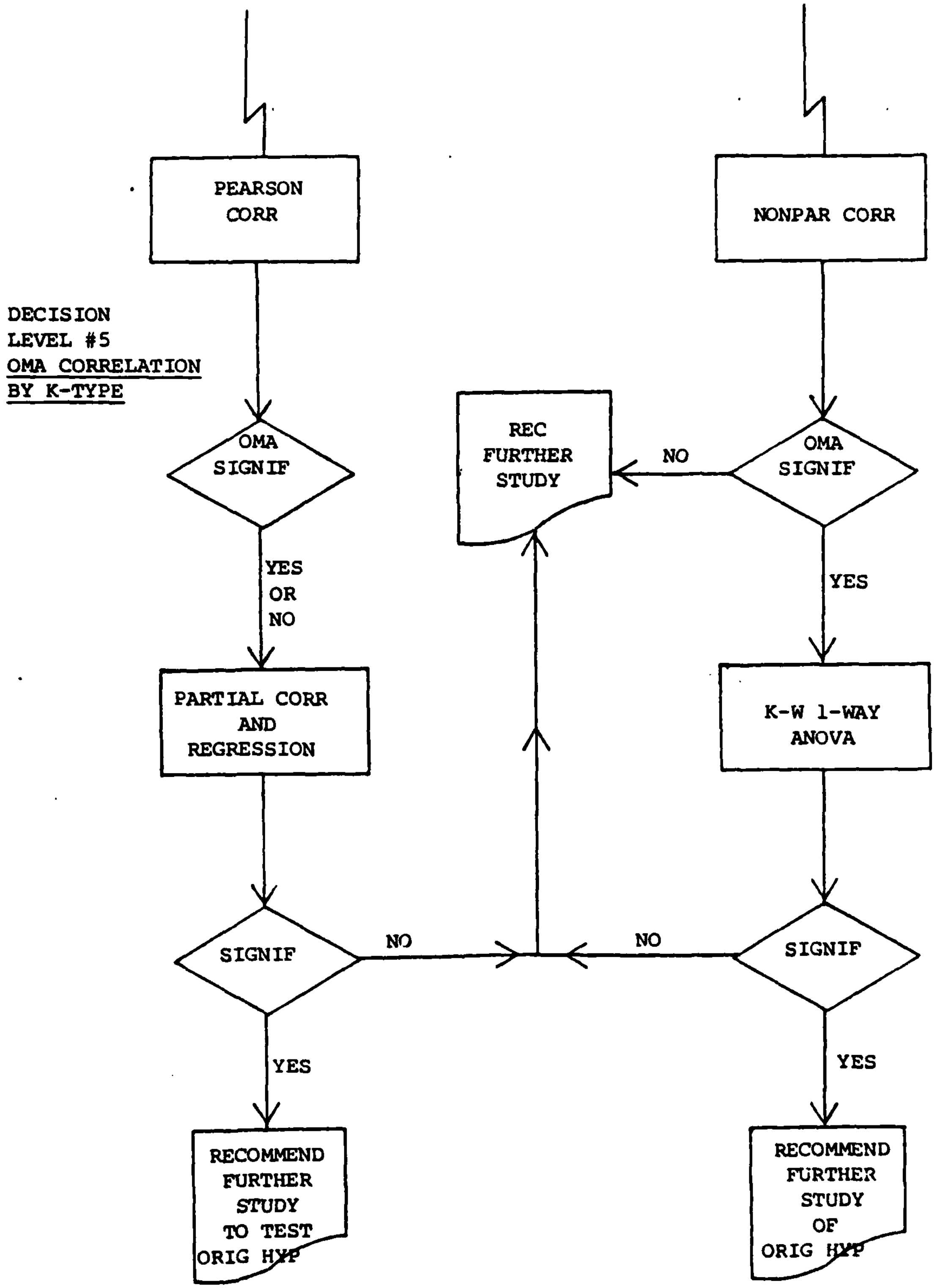


Fig. 4-1--Continued

the chance for further study. This would allow cost and other considerations to prevail in future research decisions, rather than ruling out possibilities for further study by adherence to the more stringent decision criterion necessary for hypothesis testing. Where more than one test name appears, the results of previous tests which provide for necessary statistical assumptions will determine the choice (parametric versus nonparametric procedures). The recommendations illustrated represent logical conclusions which could have been reached through a particular decision path. The discussion of each step, its objectives, rationale, assumptions, and decision criteria comprise the balance of this chapter.

Delimitation of Procedures

Decision Level #1

At decision level #1, the researchers would study the data arrangement for indications of its parameters, normality, and possible linear associations. Specific techniques to be used were SPSS SCATTERGRAM, RUNS, and K-S TEST. The RUNS Test would be employed to satisfy the researchers' concerns about the randomness of such a small, stratified sample. Although seven of twelve operational ARRCOM GOCO plants were sampled, the wide deviations in volume and type product raised concern as to whether cost data, which are known to be a function primarily of product

type and volume in the production arena, could satisfy tests of randomness necessary for statistical inference. The K-S Test for normality was to determine if parametric procedures, which are much more descriptive and widely available than nonparametric procedures, could be used to test the data. The scattergram plots were to allow study of the cost distributions, searching for possible transformations which would yield sufficient linearity for subsequent analysis through regression techniques. Simple logarithmic transformations would be made to check for smoothing of curvilinear relationships.

A brief discussion is appropriate at this point concerning the meaning of the specified alpha risk and its application to this research. The alpha risk is the probability of making an error in rejecting the null hypothesis when it is in fact true (13:262). The null hypothesis is assumed to be correct unless proven otherwise, so in effect, statistical tests do not prove the null hypothesis true, but simply reject or fail to reject it.

The specification of an alpha risk is the action taken by the researchers to determine the probability of rejecting the null hypothesis when it is in fact true. The conclusion made by specifying a wide margin of safety (i.e., high alpha risk) is acknowledgement that a high risk exists of making a mistake in failing to reject the null, when in fact, it is false. This second error, called beta

or type II error, is more difficult to define as it is determined by the magnitude of the possible error. It can range from zero to the complement of the alpha risk (1-alpha). The researcher makes his decision based upon the consequences of each error and the best compromise for the decision under study.

In this research, two separate alpha risks were employed. At decision level one, the alpha for normality was set at .20, in order to minimize the risk of testing the cost distributions with tests for which the basic underlying assumptions were false.

The specified alpha for all further testing was set at .10. This interval was considered to be the maximum width feasible with which to answer the research questions.

Decision Level #2

The tests at decision level #2 would answer research question #1. Depending upon the results of decision level #1, the appropriate test would determine the presence of significant correlation among the cost elements which comprise total contract cost. If no significant correlation was found, the decision flow would move to decision level #4, bypassing #3, as the supplemental questions to research question #1 are conditioned upon an affirmative response to the primary question.

Decision Level #3

Given significant correlations in decision level #2, further analysis of the same test results could reveal correlation between OMA costs and other cost elements. A negative response to supplemental research question #1a would effect a movement to decision level #4. However, if the research was following the nonparametric path, a positive response would also cause movement to level #4 due to a lack of nonparametric partial correlation techniques which yield statistical significance levels. If correlation was found on the parametric path and the underlying distribution had no discernible linear relationship, a recommendation for further study of possible curvilinear relationships would be made. Investigation of possible curvilinear relationships involving polynomial interactions would require intimate knowledge of logical combinations of data elements, and this was deemed beyond the scope of this research.

Given a linear relationship, preliminary study of possible causal relationships by regression analysis would be conducted. Regression analysis using both hierarchical and stepwise regression techniques in accordance with path analysis theory was determined to be within the scope of this research. An analysis for intervening effects on OMA by contract type could show effects on other variables as well. If the intervening effect was seen to extend to

total cost there would be an affirmative answer to supplementary research question #1b.

Decision Level #4

At decision level #4, appropriate correlation tests would be conducted for each group of contract type to determine possible significant changes in correlation between cost elements for each contract type. The results of this comparison would answer research question #2. If no significant changes were found, a recommendation for no further research toward the original hypothesis of this research would be appropriate. The decision rule for significant change in correlations was formulated by the researchers. If any correlation coefficient between like elements lost its significance, gained significance, or significantly changed its direction (sign), when observed from one contract type to another, then significant change would be found. This would yield an affirmative answer to research question #2. Changes in the magnitude of the coefficients themselves, without a change in significance, would be statistically inconclusive. Inconclusive findings at this decision level would terminate the formal portion of this research with a negative response to research question #2.

Decision Level #5

Actions at decision level #5 would differ from other levels if the parametric path had been followed. A study of the significant changes in correlation observed at decision level #4 would seek to answer the supplemental research question #2a. Regardless of the answer, partial correlation analysis would be conducted on those cost elements which had shown significant change. It was felt by the researchers that partial correlation, controlling for the effects of OMA, might yield significant correlation changes in OMA after other cost interactions had been partialed out of the relationships. Regression analysis would also be used to determine if OMA costs had effects on total costs which were not made apparent by correlation analysis. The specific regression techniques used would combine hierarchical and stepwise regression methods. Those tests would enable the researchers to conclusively answer supplemental research questions #2b and #2c, and make the appropriate recommendations for further study.

If the nonparametric path to decision level #5 had been followed, further study of the significant changes noted at decision level #4 would be conducted to seek an answer to supplemental research question #2a. If no significant changes in OMA correlation coefficients were found, a recommendation for further study of other significant changes would be made. If OMA coefficients had changed

significantly, the Kruskall-Wallis analysis of variance test would be applied to those costs showing significant change in each group. This test would determine if significant differences between contract types were present in the actual cost elements. While the findings of such a test would be inconclusive in regard to supplemental research questions #2b and #2c, it was felt that the results would provide meaningful information upon which to base a recommendation for further study of the original research hypothesis. The additional information was determined to be necessary because meaningful partial correlation techniques for nonparametric data were not available to the researchers.

The research was conducted according to this plan. The findings obtained are presented in Chapter V.

CHAPTER V

ANALYSIS OF THE DATA

Introduction

This chapter contains the findings of the researchers at each level of the decision process. The results of the statistical tests and the answers, as appropriate, to the research questions are included at each decision level. Additional statistical observations of the test results are noted, as appropriate.

Findings at the Decision Levels

Decision Level #1

At decision level #1, the researchers first obtained a scatter plot showing the relationship between H, total contractor cost, and OMA, operation and maintenance costs (Figure 5-1). The initial plots utilized all cost elements obtained in the sample. They revealed no clear linear relationship. The plots of transformed data from the total sample are at Appendix A.

A scatter plot was then constructed from only those data elements shown as monthly totals of cost elements. A reasonably linear association between monthly totals cf OMA and total cost was illustrated (Figure 5-2). Taking note of the distinct outlying values at the top and bottom

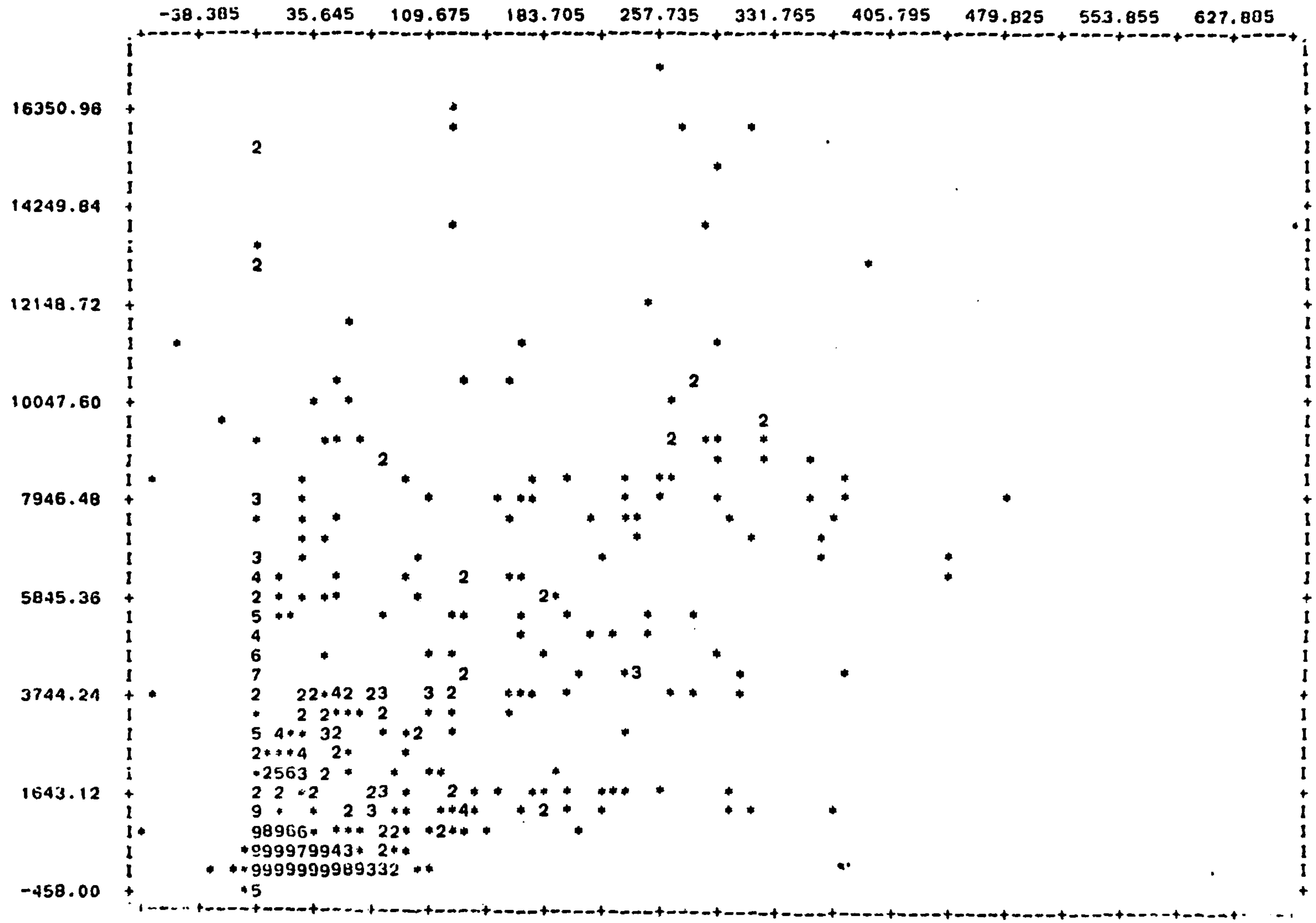


Fig. 5-1. Plot of H with OMA--Whole Sample

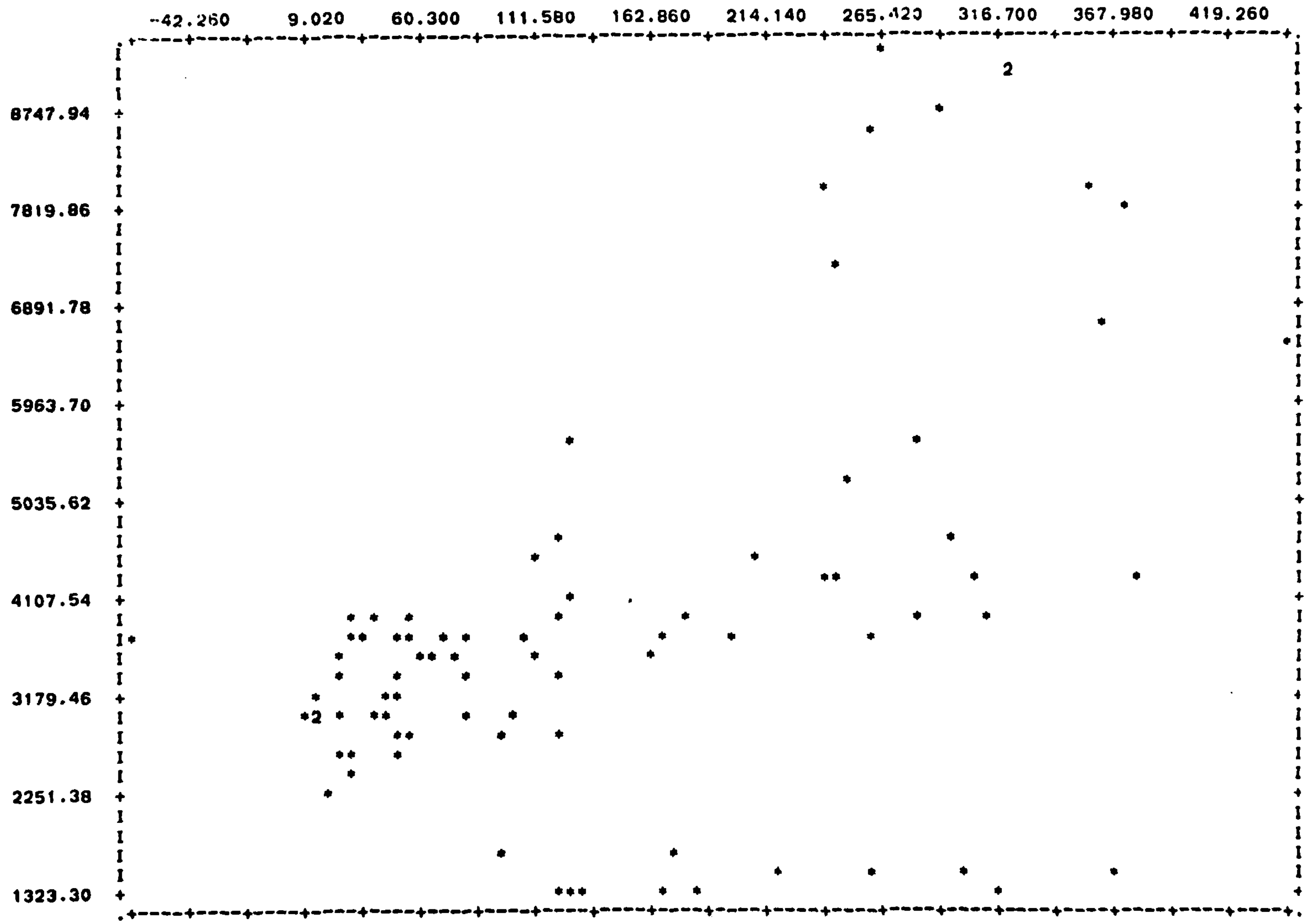


Fig. 5-2. Plot of H with OMA--Monthly Total Cost

right side of the plots, the researchers made several attempts at data transformation to achieve a closer linear association. The first transformation consisted of dividing each cost element by the square footage of its respective plant facility. The next transformation divided that adjusted data by the average direct labor hours for each respective month. Plant square footage was used to attempt compensation in data appearance for the varying sizes of the GOCO plants under consideration. Direct labor hours were used to compensate for varying levels of output among the plants, and was chosen specifically because it is a common means of allocation of indirect cost (10:111). Thus, it would effectively compensate for varying output levels and methods of overhead allocations. The results of each transformation served chiefly to reduce the scales of the scatter plots, and to somewhat visually degrade the linear association previously observed (Appendix A). The researchers discarded the adjusted data, returning to the original associations. Further study of the plots in Figure 5-2 suggested a possible curvilinear relationship with some spurious values along the bottom of the plot. A transformation of the data points to natural (napierian) logarithms was effected to examine a possible curvilinear association. The resultant plot at Figure 5-3 revealed a flattening of the slope of the central plots and line, along with more separation between them. The increased

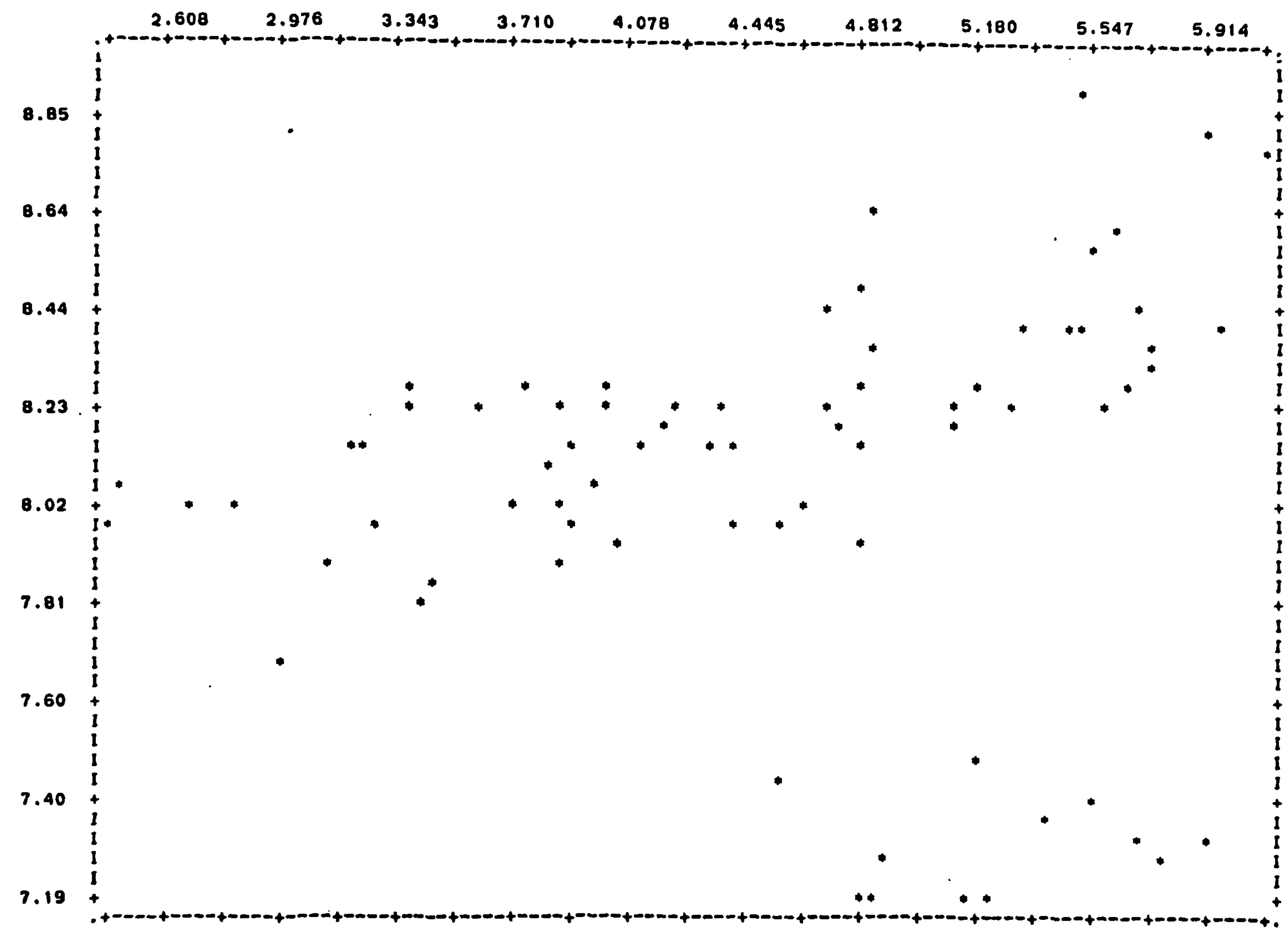


Fig. 5-3. Plot of H with OMA (Monthly)--Logarithms

distinction of the plots grouped at the upper right and lower right corners of the figure caused misgivings about the underlying distribution of costs and the sample distribution. This transformed data was also discarded.

The researchers then conducted tests for the randomness and normality of the sample distribution of total cost. The procedure selected was SPSS NPAR Tests with subroutines RUNS above and below the sample median and K-S (Kolmogorov-Smirnov) goodness of fit. The results are shown in Table 5-1. The significance level for randomness of the sample was set at .10 to allow conservative deviations from randomness. The RUNS test was evaluated as a two-tailed test, as any departure from randomness was undesirable. Since the significance of the number of runs was greater than .10, the test failed to reject the null hypothesis of the sample being random or not departing markedly therefrom.

The K-S test for goodness of fit required use of the Lilliefors test tables since the population and standard deviation of total cost was estimated from the sample. The significance level for the test for normality was set at .20 to allow conservative deviation from normality but not extreme deviation, which would render the validity of further parametric testing somewhat questionable. The maximum absolute deviation from the proposed population computed by SPSS exceeds .0803, the Lilliefors critical statistic. This indicated that the sample

TABLE 5-1

TESTS FOR RANDOMNESS AND NORMALITY

RUNS TEST - TEST VALUE: MEDIAN

H TOTAL

CASES	TEST VALUE	RUNS	LT	GE
84	3722.8000	46	42	42

Z	2-TAILED P
.6586	.5101

KOLMOGOROV - SMIRNOV GOODNESS OF FIT TEST

H TOTAL

TEST DIST. - NORMAL MEAN = 4062.0488
STD. DEV. = 2077.1235)

CASES	MAX(ABS DIFF)	MAX(+ DIFF)	MAX(- DIFF)
84	.2056	.2056	-.0937

K-S Z	2-TAILED P
1.884	.002

LILLIEFORS TEST STATISTIC: $T_{CRITICAL} = \frac{.736}{\sqrt{n}} = \frac{.736}{\sqrt{84}} = .0803$

distribution of total contractor costs was skewed too far to the right to be considered a random sample from a normal distribution. The lack of normality of the sample of total contractor costs directed further study to the nonparametric path through the decision levels.

Additional tests for normality and randomness were conducted on the data available. The results are included at Appendix B. The researchers felt that arbitrary division of the sample into subsamples not included in the original sampling plan would be abusive of statistical processes. Therefore, their results were discarded.

Decision Level #2

At decision level #2, SPSS subroutine NONPAR CORR was utilized to compute correlation coefficients and their two-sided significance probabilities, for each and all variables which comprised total cost in the sample studied (monthly contractor total costs). Subroutine NONPAR CORR generated both Spearman's r_s and Kendall's Tau correlation coefficients. Both statistics are derived from rank-ordering methods. Spearman's correlation coefficients are more commonly used and are felt to more closely approximate product moment coefficients computed under assumptions of normality. Kendall's Tau is felt to be more meaningful if the data contain a large number of ties in rankings, a not too uncommon occurrence in ordinal data (14:289).

Since the cost data under study could be assumed to have an essentially continuous distribution, the Spearman coefficients were chosen for this study and will be referred to hereafter as simply correlation coefficients. The Kendall correlation coefficients are included at Appendix C. The level of significance for hypothesis testing of correlation coefficients was .10. A two-tailed test was chosen since the null hypothesis that no correlation exists can be rejected by significant evidence of either positive or negative correlation. As this study was exploratory in nature, it was felt that findings of significant correlations with 90 percent confidence were appropriate. All computed coefficients are displayed in the tables so that independent study at other confidence levels can be conducted on the same data.

The first task at decision level #2 was to answer research question #1. Examination of the coefficients and significance probabilities shown in Table 5-2 revealed significant correlation between all variables except between direct production costs (A) and direct OMA costs (E), and between indirect production costs (B) and both direct and indirect OMA costs (F). Of particular significance was the observation of the highest correlation being between direct and indirect OMA costs (E&F) of any pair of costs, and the observation that all component variables had a higher correlation with total cost (H) than with their

TABLE 5-2

CORRELATION COEFFICIENTS OF INDIVIDUAL COST ELEMENTS

VARIABLE PAIR		VARIABLE PAIR		VARIABLE PAIR	
A WITH B	.3545 SIG .001	A WITH C	.3849 SIG .001	A WITH D	.4243 SIG .001
A WITH E	.1790 SIG .104	A WITH F	.3195 SIG .004	A WITH H	.6344 SIG .001
B WITH C	.3844 SIG .001	B WITH D	.5697 SIG .001	B WITH E	.1395 SIG .206
B WITH F	-.0465 SIG .675	B WITH H	.7508 SIG .001	C WITH D	.7122 SIG .001
C WITH E	.3802 SIG .001	C WITH F	.2650 SIG .015	C WITH H	.7926 SIG .001
D WITH E	.4514 SIG .001	D WITH F	.3260 SIG .003	D WITH H	.7242 SIG .001
E WITH F	.8595 SIG .001	E WITH H	.4577 SIG .001	F WITH H	.3519 SIG .002

companion variables in each major component of cost by fund source (A&B = production, C&D = nonproduction, E&F = OMA). The one exception was the correlation between direct and indirect OMA costs (E&F). In answer to research question #1, there is a significant degree of correlation between the various elements which comprise total contractor cost. With an affirmative answer, the researchers moved to decision level #3.

Decision Level #3

Study of the coefficients to determine correlation with OMA was accomplished by grouping direct and indirect OMA costs (E&F) into one variable called OMA. To show complimentary correlations for further study, the other components were also grouped into their fund source categories. The resultant coefficients are shown in Table 5-3. All basic cost elements were found to be significantly correlated to aggregate OMA costs except indirect production costs (B). This lack of correlation apparently acted to produce the insignificant correlation coefficient between production and OMA costs. Although the correlation coefficient between OMA and total cost (H) was significant, it indicated appreciably less correlation between OMA and total cost than the effects of production and nonproduction costs. The study of results in Table 5-3 indicated a positive response to research question #1a, showing significant

TABLE 5-3

CORRELATION COEFFICIENTS COMBINED BY FUND SOURCE

VARIABLE PAIR		VARIABLE PAIR		VARIABLE PAIR	
A WITH OMA	.2265 SIG .039	B WITH OMA	.0823 SIG .457	C WITH OMA	.3575 SIG .001
D WITH OMA	.4245 SIG .001	H WITH OMA	.4357 SIG .001	PROD WITH NONPROD	.3576 SIG .001
PROD WITH OMA	.1554 SIG .159	PROD WITH H	.7689 SIG .001	NONPROD WITH OMA	.3990 SIG .001
NONPROD WITH H	.8273 SIG .001				

correlation between OMA costs and other cost elements comprising total cost.

All statistical techniques used to study partial correlations which were available to the researchers required assumptions of normality. Therefore, the researchers proceeded to decision level #4, leaving supplemental research question #1b indeterminate.

Decision Level #4

To answer research question #2, the researchers divided the sample of total costs into groups by contract type. Correlation coefficients were computed for the different cost elements and are presented in Table 5-4. By comparing the results of each column, the researchers noted that fifteen (15) of the twenty-one (21) correlation coefficients had changed significantly among the contract types. It should be noted that the categories of cost comprising OMA (E&F), did not change in their relation to total contract cost (H). In answer to research question #2, the elements of cost showed significant change in correlation among the three types of contracts. The process of analysis then moved to decision level #5.

Decision Level #5

To answer supplemental research question #2a, the researchers grouped direct and indirect cost into variable OMA and computed correlation coefficients between OMA and

TABLE 5-4

CORRELATION COEFFICIENTS OF INDIVIDUAL COST ELEMENTS
GROUPED BY CONTRACT TYPE

VARIABLE PAIR	TYPE CPFF	TYPE CPIF	TYPE CPAF
A WITH B	.8988 SIG .001	.3304 SIG .115	-.2304 SIG .279
A WITH C	.8960 SIG .001	-.2739 SIG .196	-.3104 SIG .140
A WITH D	.7537 SIG .001	-.2979 SIG .158	.7017 SIG .001
A WITH E	.3372 SIG .045	-.0739 SIG .732	.4983 SIG .014
A WITH F	.2288 SIG .180	-.0626 SIG .772	.7184 SIG .001
A WITH H	.9650 SIG .001	.2043 SIG .339	.3983 SIG .054
B WITH C	.8497 SIG .001	.1696 SIG .429	.0548 SIG .800
B WITH D	.7892 SIG .001	.3418 SIG .103	-.4061 SIG .049

TABLE 5-4--Continued

VARIABLE PAIR	TYPE CPFF	TYPE CPIF	TYPE CPAF
B WITH E	.3853 SIG .021	.1652 SIG .441	-.5443 SIG .006
B WITH F	.3248 SIG .054	.1774 SIG .407	-.4766 SIG .019
B WITH H	.9624 SIG .001	.5957 SIG .003	.1661 SIG .438
C WITH D	.7475 SIG .001	.8180 SIG .001	-.0870 SIG .687
C WITH E	.3519 SIG .036	.7930 SIG .001	.0626 SIG .772
C WITH F	.2283 SIG .181	.7426 SIG .001	-.1883 SIG .379
C WITH * H	.9189 SIG .001	.7557 SIG .001	.5913 SIG .003
D WITH * E	.5990 SIG .001	.7345 SIG .001	.6896 SIG .001

* Indicates No Change.

TABLE 5-4--Continued

VARIABLE PAIR	TYPE CPFF	TYPE CPIF	TYPE CPAF
D WITH * F	.6049 SIG .001	.7406 SIG .001	.7584 SIG .001
D WITH * H	.8015 SIG .001	.7554 SIG .001	.3609 SIG .084
E WITH * F	.8867 SIG .001	.9635 SIG .001	.8576 SIG .001
E WITH * H	.3588 SIG .032	.7139 SIG .001	.4800 SIG .018
F WITH H	.2718 SIG .109	.7113 SIG .001	.3949 SIG .057

* Indicates No Change.

each of the other cost elements. For further analysis, the other cost elements were also grouped into their major categories by fund source; direct and indirect production costs (PROD), and direct and indirect nonproduction costs (NONPROD). Correlation coefficients between each fund source category and total cost (H) were computed for each contract type. All coefficients are displayed at Table 5-5. The researchers noted that the correlation coefficients between OMA and total cost remained unchanged for each contract type. Correlation coefficients for OMA and the elements of production costs (A&B), and direct nonproduction costs (B) changed significantly. These changes remained significant when the cost elements were grouped by fund source. Supplemental research question #2a received an affirmative response, as the elements of OMA did show significant change in correlation among contract types. Supplemental research questions #2b and #2c were indeterminate by nonparametric tests.

The Kruskall-Wallis test was conducted on all elements of total cost. The results are presented in Table 5-6. The researchers noted that all costs were seen to differ significantly by contract type except total contractor cost. This finding raised significant questions which are addressed in the concluding chapter.

TABLE 5-5

CORRELATION COEFFICIENTS COMBINED BY FUND SOURCE AND GROUPED BY TYPE

VARIABLE PAIR	TYPE CPFF	TYPE CPIF	TYPE CPAF
A WITH OMA	.2978 SIG .078	-.1078 SIG .617	.5983 SIG .003
B WITH OMA	.3647 SIG .029	.1670 SIG .436	-.5539 SIG .005
C WITH OMA	.3207 SIG .057	.7791 SIG .001	-.0130 SIG .952
D WITH * OMA	.6093 SIG .001	.7563 SIG .001	.7574 SIG .001
H WITH * OMA	.3302 SIG .050	.7052 SIG .001	.4774 SIG .019
PROD WITH NONPROD	.9145 SIG .001	-.1774 SIG .407	-.2096 SIG .326
PROD WITH OMA	.2898 SIG .087	-.0565 SIG .794	.3678 SIG .077

* Indicates <u>No</u> Change.

TABLE 5-5--Continued

VARIABLE PAIR	TYPE CPFF	TYPE CPIF	TYPE CPAF
PROD WITH * H	.9869 SIG .001	.3843 SIG .064	.5296 SIG .008
NONPROD WITH OMA	.3279 SIG .051	.7878 SIG .001	.0478 SIG .825
NONPROD WITH * H	.9251 SIG .001	.7435 SIG .001	.6209 SIG .002
OMA WITH * H	.3302 SIG .050	.7052 SIG .001	.4774 SIG .019

* Indicates No Change.

TABLE 5-6

KRUSKALL-WALLIS ONE-WAY ANOVA

CHECK FOR DIFF FOR DIFF K-TYPE; (1) CPFF , (2) CPIF, (3) CPAF

PRODUCTION DIRECT
A
BY KTYPE

KTYPE	1	2	3
NUMBER	36	24	24
MEAN RANKS	35.44	57.46	38.13

CASES = 84
CHI-SQUARE = 12.809
SIGNIFIANCE = .002

PRODUCTION INDIRECT
B
BY KTYPE

KTYPE	1	2	3
NUMBER	36	24	24
MEAN RANKS	50.83	25.53	46.88

CASES = 84
CHI-SQUARE = 16.460
SIGNIFICANCE = .000

NONPRODUCTION DIRECT
C
BY KTYPE

KTYPE	1	2	3
NUMBER	36	24	24
MEAN RANKS	35.97	41.75	53.04

CASES = 84
CHI-SQUARE = 7.083
SIGNIFICANCE = .029

NONPRODUCTION INDIRECT
D
BY KTYPE

KTYPE	1	2	3
NUMBER	36	24	24
MEAN RANKS	41.25	27.17	59.71

CASES = 84
CHI-SQUARE = 21.525
SIGNIFICANCE = .000

TABLE 5-6--Continued

CHECK FOR DIFF FOR DIFF K-TYPE; (1) CPFF, (2) CPIF, (3) CPAF

OMA DIRECT
E
BY KTYPE

KTYPE	1	2	3
NUMBER	36	24	24
MEAN RANKS	54.97	34.67	31.62

CASES = 84
CHI-SQUARE = 16.657
SIGNIFICANCE = .000

OMA INDIRECT
F
BY KTYPE

KTYPE	1	2	3
NUMBER	36	24	24
MEAN RANKS	49.94	47.08	26.75

CASES = 84
CHI-SQUARE = 14.206
SIGNIFICANCE = .001

TOTAL
H
BY KTYPE

KTYPE	1	2	3
NUMBER	36	24	24
MEAN RANKS	43.56	38.92	44.50

CASES = 84
CHI-SQUARE = .747
SIGNIFICANCE = .688

FUND SOURCE PRODUCTION
PROD
BY KTYPE

KTYPE	1	2	3
NUMBER	36	24	24
MEAN RANKS	50.19	35.25	38.21

CASES = 84
CHI-SQUARE = 6.445
SIGNIFICANCE = .040

TABLE 5-6--Continued

FUND SOURCE NONPRODUCTION				FUND SOURCE OMA			
NONPROD				OMA			
BY KTYPE				BY KTYPE			
KTYPE	1	2	3	KTYPE	1	2	3
NUMBER	36	24	24	NUMBER	36	24	24
MEAN RANKS	37.69	39.46	52.75	MEAN RANKS	53.56	38.58	29.83
CASES = 84				CASES = 84			
CHI-SQUARE = 5.008				CHI-SQUARE = 14.486			
SIGNIFICANCE = .050				SIGNIFICANCE = .001			

Summary of Findings

The findings were summarized to restate the research questions and their answers as follows:

1. Do any statistically significant correlations exist between the cost elements which comprise total contractor costs in operation of GOCOs? Yes, all cost elements are correlated with each other except for indirect production costs with the elements of operation and maintenance costs.

a. Are operation and maintenance costs among those with significant correlation? Yes.

b. Do the effects of operation and maintenance costs upon total cost change significantly when all other cost effects are controlled? This question could not be answered with the nonparametric tests available to the researchers.

2. Do any significant changes occur among the correlation coefficients between the cost elements which comprise total contractor cost in operation of GOCOs when the elements are separated into groups by type of contractual arrangement? Yes, fifteen of the twenty-one pairs of cost elements showed a significant change in correlation among groupings by contract type.

a. Are operation and maintenance costs among those with a significant change? Yes, all operation and maintenance costs show a significant change in correlation

among groups by contract type, but none show change with respect to total cost.

b. Do the effects of operation and maintenance costs upon total cost change significantly when the other cost effects are controlled? This question could not be answered with the nonparametric tests available to the researchers.

c. Does this significance differ by type of contractual arrangement? This question could not be answered with the nonparametric tools available to the researchers.

The observations and findings which did not specifically serve to answer the research questions, but which were pertinent to the research objective, are summarized and discussed in the concluding chapter.

CHAPTER VI

CONCLUSIONS AND RECOMMENDATIONS

Introduction

In conducting this study the researchers made every attempt to avoid the introduction of personal and statistical bias to the results. In this chapter, the researchers' opinions concerning the results, inferrences, and implications of the findings are presented for each research question. Following the conclusions, recommendations for follow-on study and additional study are made.

Conclusions

Distribution of the Population

The findings at decision level #1 indicated that parametric procedures of analysis will not be possible in any future study of total contractor costs. This indication must be tempered with the knowledge that the total number of GOCO plants studied was only seven, a very small sample. The additional scatter plots and normality tests at Appendices A and B tend to undermine the findings at decision level #1, but they were not used in this study. The researchers could not place sufficient statistical validity in the results of the additional tests to answer the research questions, but they felt compelled to include

them for comparison with the relevant scatter plots. Such a comparison supports the researchers' observations at decision level #1 of the possibility of two or more distinct distributions being present in the sample. Although the results of tests at decision level #1 rule out parametric study of GOCOs as a whole, the additional tests suggest the possibility of parametric comparison studies of the separate distributions of each contract type.

The findings at decision level #1 also strongly suggest that the cost-accumulating nature of the production functions and overhead rates under the different contract types might yield to some normalizing data transformation. This was indicated by the "flattening" effect that the logarithmic transformations had on the data. As illustrated in the scatter plots, this effect was not uniform, but that could have been due to the researchers' use of the same normalizing transformation factor in all plants.

Research Question One

At decision level #2 the direct and indirect operation and maintenance cost elements were not found to be significantly related to the direct amounts of production cost, nor were they significantly related to either direct or indirect nonproduction costs. These findings suggest that any preconceived notion that operation and

maintenance costs are dependent upon the product being made in a plant, or upon the level of production, should be discarded. This finding was considered crucial to further study of operation and maintenance costs. If operation and maintenance costs were related to elements of production, then future attempts to isolate the production relationships, in order to study OMA under differing management structures, could be exceedingly difficult. The absence of significant correlation in this area, coupled with the distribution possibilities discussed above, indicate good possibilities for significant research into the relationship between OMA and total costs.

The findings at decision level #3 indicate that OMA costs maintain their significant relationships with other costs when the costs are grouped into their fund source categories. This finding was considered highly significant to the issue of cost in future data collection efforts. Although future study of the individual cost elements would be more precise, these findings indicate that OMA costs could be studied effectively in their aggregate. As was noted in Chapter III, the aggregation of such cost data was originally felt to render the research hypothesis untestable. The findings at decision level #3 indicate otherwise. The absence of any significant negative correlation coefficients at decision level #2 strengthens this finding. Their absence indicates that no

significant relationships exist which would tend to counteract the impact on total cost of a reduction in operation and maintenance costs.

Research Question Two

The findings at decision level #4 give strong indications that some element or function of structure has a definite impact on the cost elements of production. Both of the elements of production and the direct element of nonproduction showed changes in their correlation by contract type. When the costs were aggregated at decision level #5, the same pattern of change was noted. The failure of OMA costs to show significant change between contract type at both decision levels is significant. This is an indication that the relationship between OMA and total cost is not influenced by type of contract. This should not lead to a conclusion that the interaction between total cost and OMA is independent of any structural variable. Further study of the test results shows significant changes in the relationships of production costs, OMA costs, and total costs. The change in correlation between production costs and OMA costs, while OMA's relationship with total cost remained constant, could be further evidence of essential independence between production costs and OMA costs. It could also indicate interaction among the three which

is not apparent, or is due to some other intervening variable.

The results of the ANOVA tests were felt to lend more weight to the findings of a masking effect of the structural variable than to the findings of an absence of structural impact. The researchers noted that at decision levels #2 and #4, production costs, nonproduction costs, and OMA costs were all significantly correlated with total costs. Yet, the ANOVA results indicated that only total costs were equal among all three groups. The researchers admit that positive correlation among contract types does not imply equality. However, the likelihood that all cost elements could be unequal among the groups, yet independently add up to equal totals, seemed remote. Although the ANOVA results could have been the result of sampling error, the researchers felt the results reinforced the possibility of one or more masking variables whose effects were to counteract the positive correlations. Since no significant negative correlations were observed at decision level #5, the researchers concluded that some intervening variable other than contract type exists.

Recommendations for Follow-on Study

The results of this research support further study into all areas of significant findings. This recommendation is tempered with a condition that the true nature of

the frequency distribution of total contractor costs be firmly established prior to other study. The findings of correlation clearly show both a positive relationship between operation and maintenance costs (OMA) and total costs (H), and no significant relationship between production costs (PROD) and operation and maintenance costs (OMA). Some structural variable was also indicated to interact with all three cost elements. This combination of interrelationships is precisely the precondition necessary for the original hypothesis of this research to be tested. However, the true nature of the unknown structural variable would be quite difficult to determine by nonparametric procedures of hypothesis testing.

Based on these reasons and the other conclusions as stated above, the researchers recommend that:

1. Further study be conducted to determine if normalization of variables can render the population frequency distribution of total contractor cost capable of being studied by parametric means.

2. Further study be conducted to determine if the distribution of total contractor cost is actually two or more distributions which may be studied independently.

3. Given success in either 1. or 2. above, further study to determine the impact of management structure on the operational costs of GOCOs should be conducted.

Recommendations for Additional Study

It was the researchers' contention throughout this study that highly significant findings would be necessary to warrant a recommendation to undertake the costs necessary to test the research hypothesis. Recognizing that further study might be desired, without a large commitment of funds to data collection implied in the previous recommendations, the researchers recommend that:

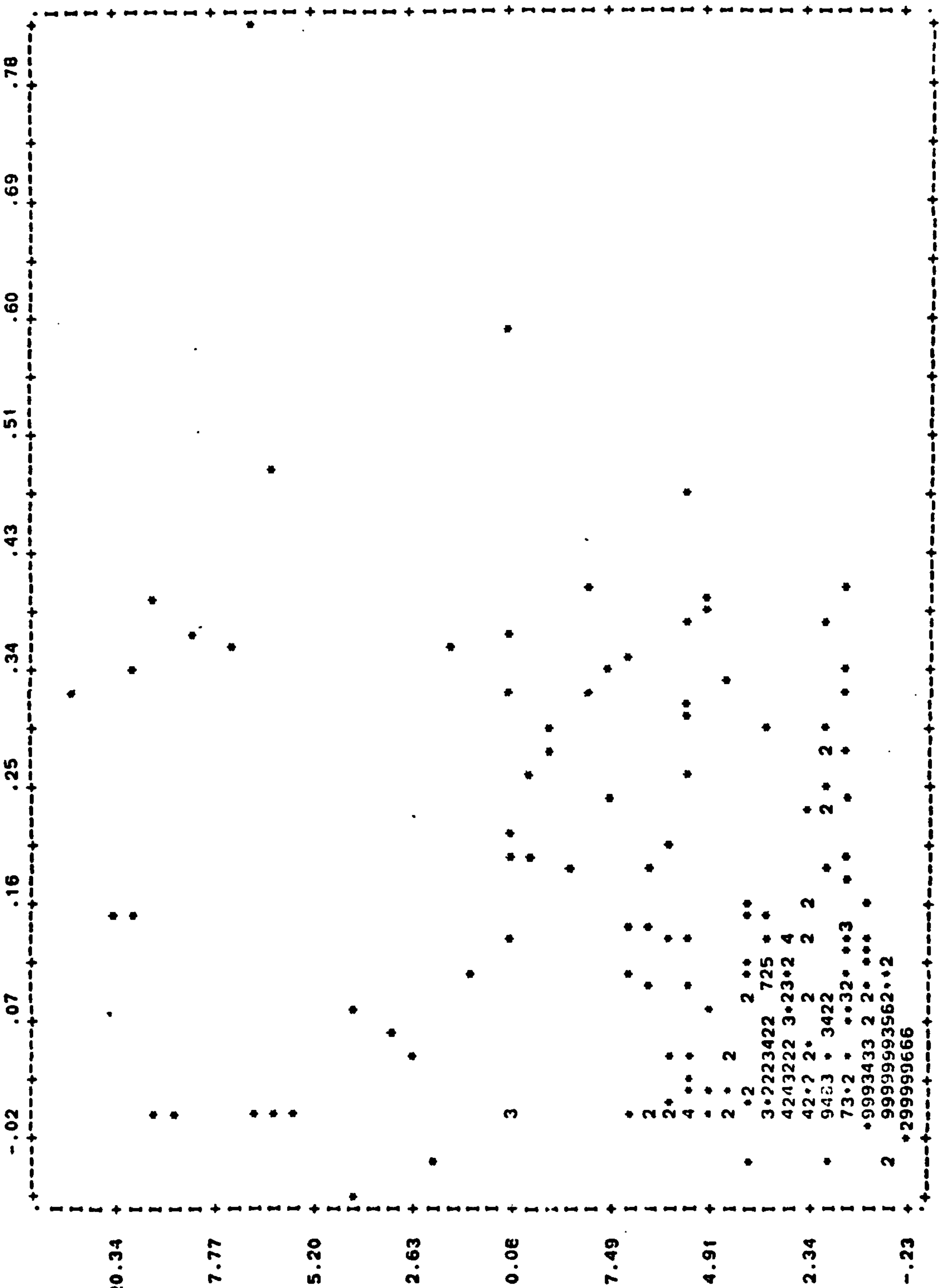
1. Additional study of the structural impact of contract type on the elements of total cost be conducted to isolate the intervening structural variable suggested to be masking the effects of contract upon total cost.

2. Additional refinement of the available data base be conducted to possibly allow nonparametric procedures to test the impact of management structure upon the elements of total contractor cost.

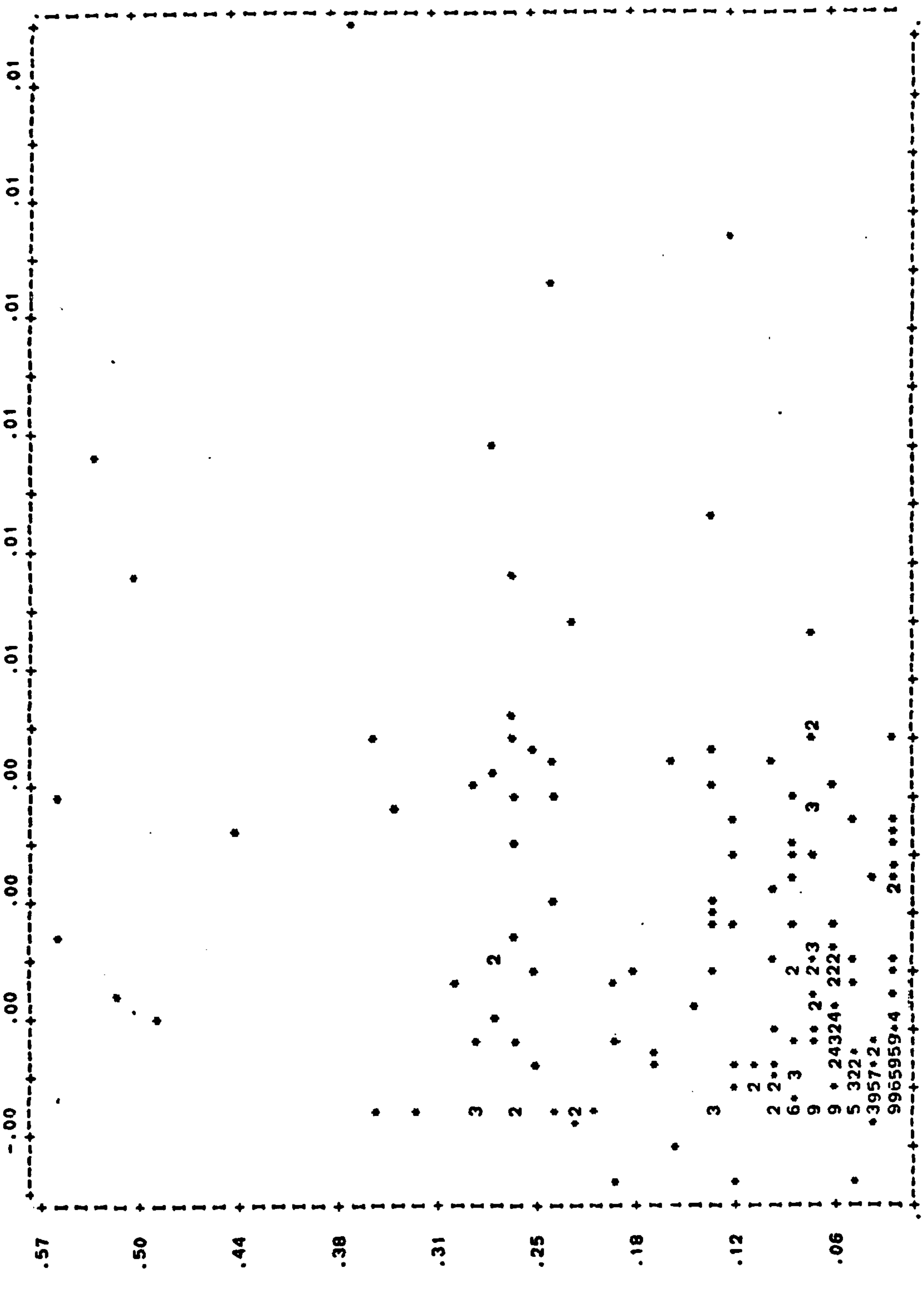
APPENDICES

APPENDIX A

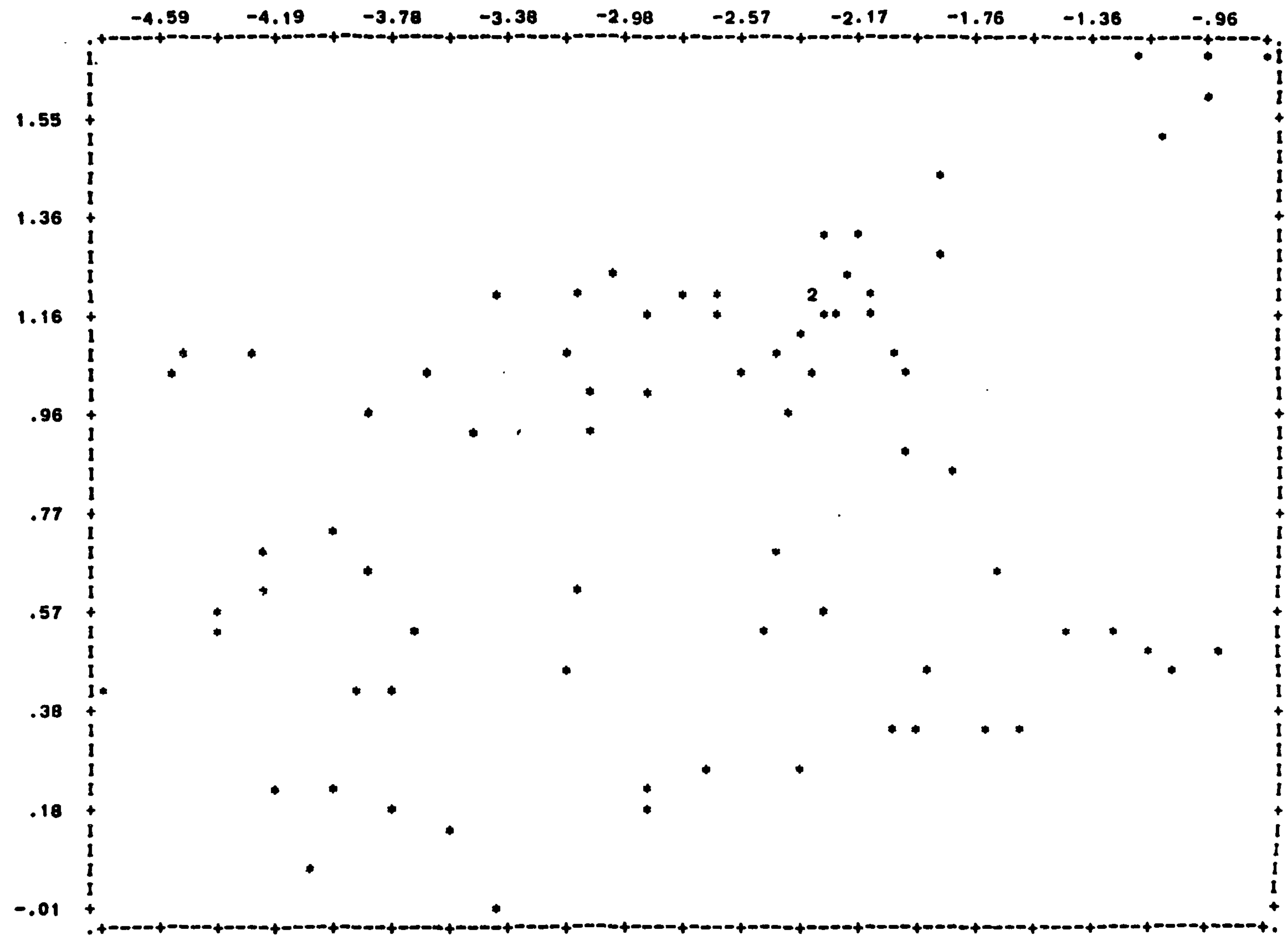
SCATTER PLOTS OF TRANSFORMED COST DATA



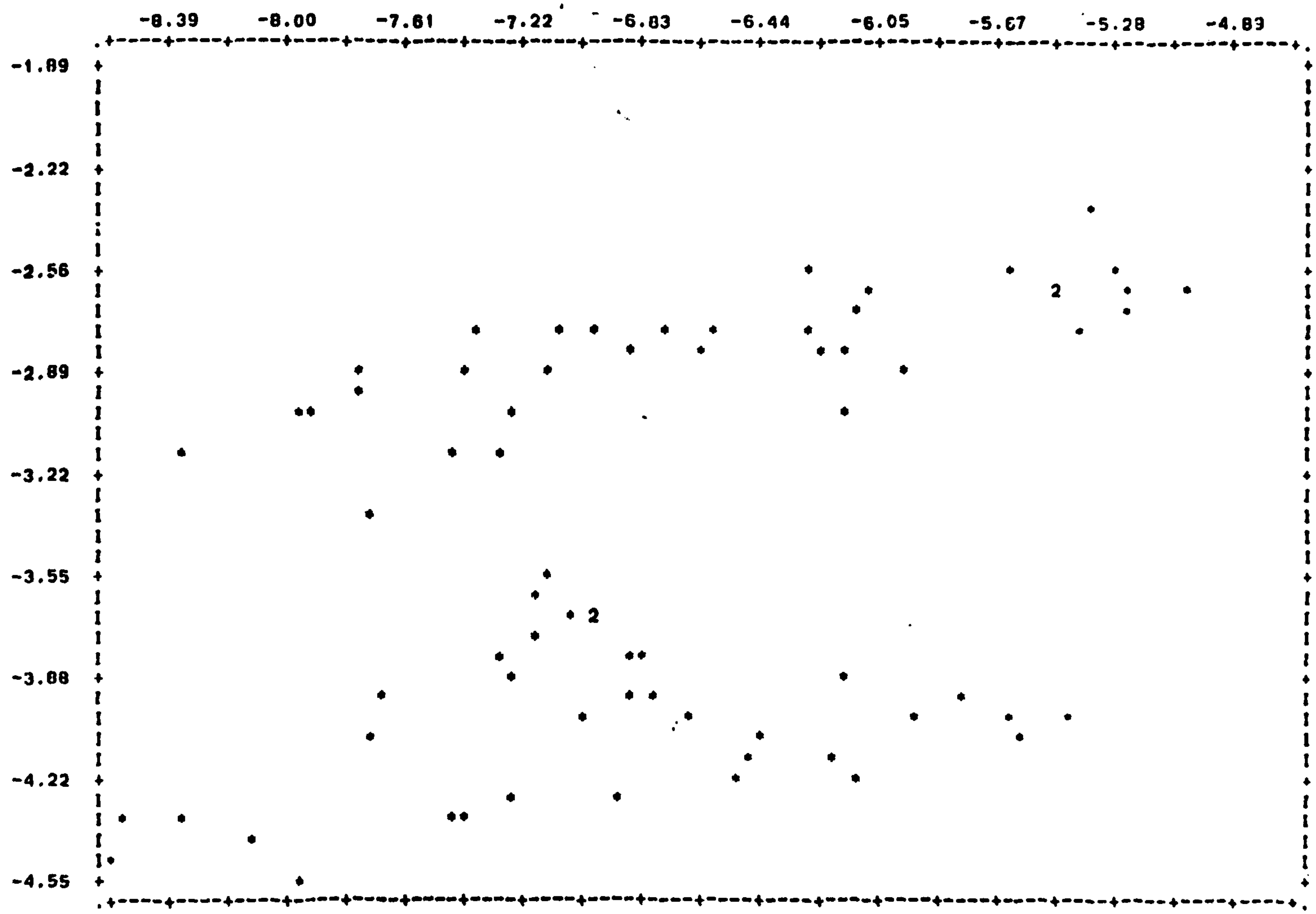
H With OMA (ALL)--Adjusted for Square Footage



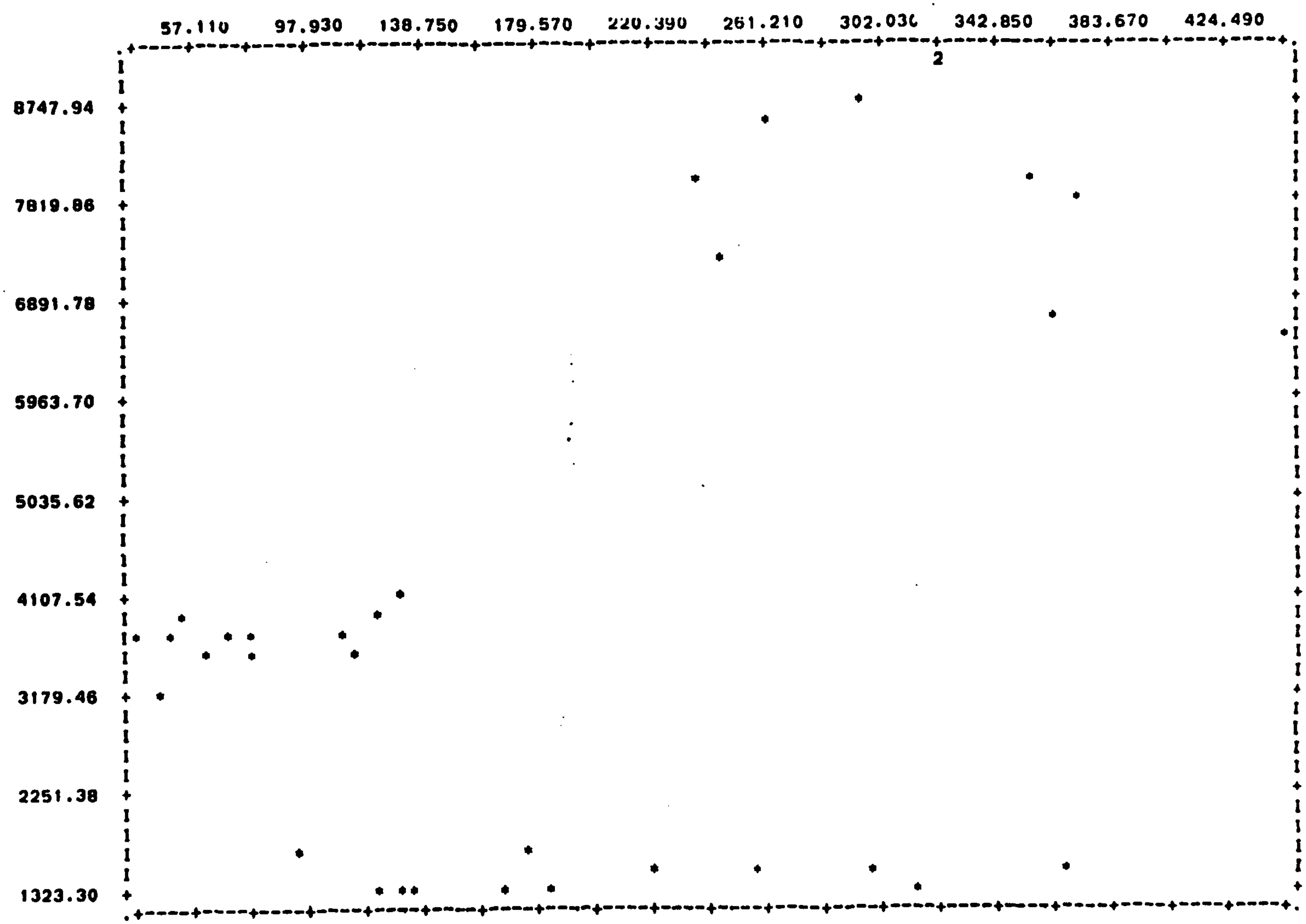
H With OMA (ALL)--Adjusted for Square Footage and Direct Labor Hours



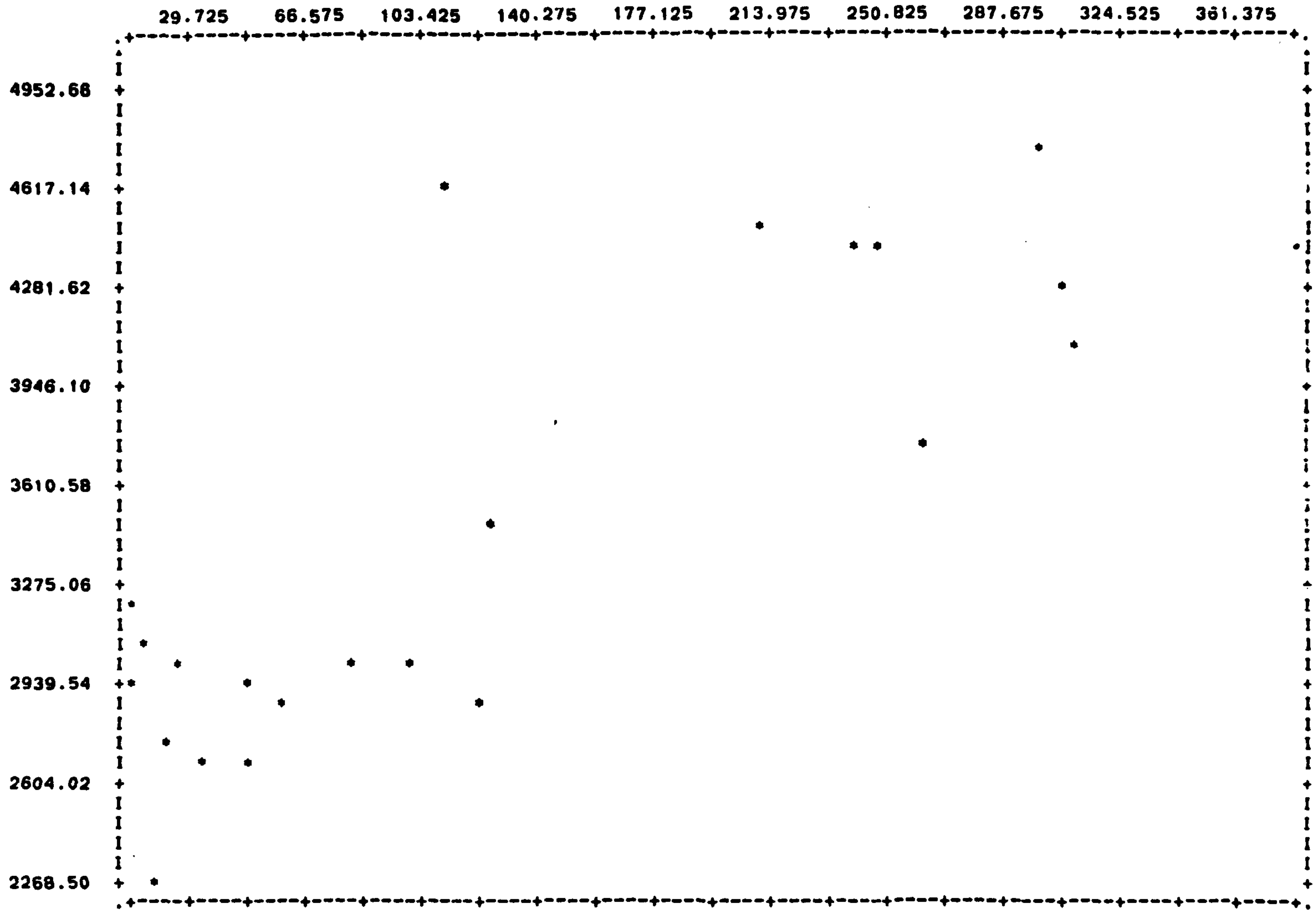
H With OMA (TOT COST)--Adjusted for Square Footage (Logarithms)



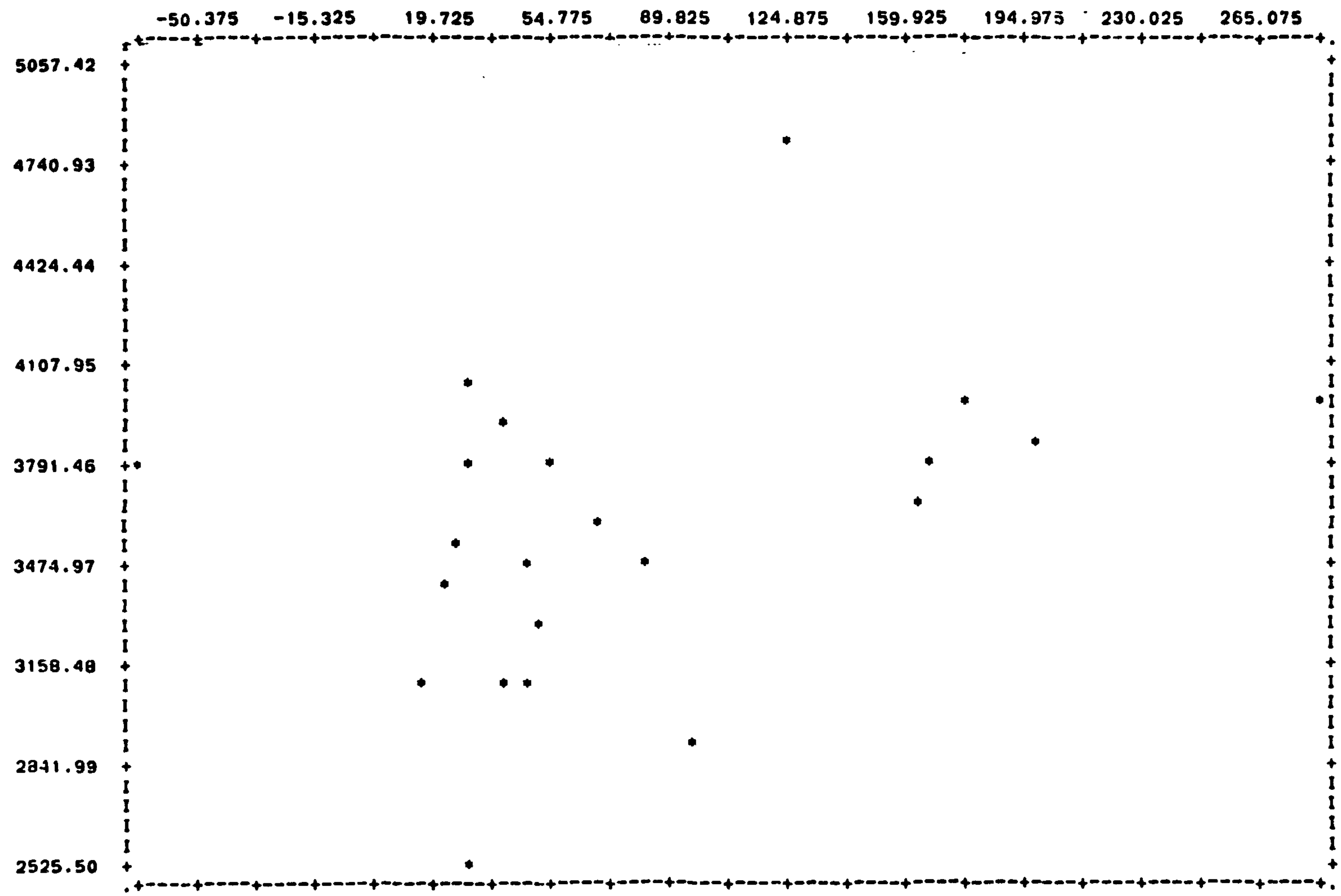
H With OMA (TOT Cost)--Adjusted for Square Footage and Direct Labor Hours (Logarithms)



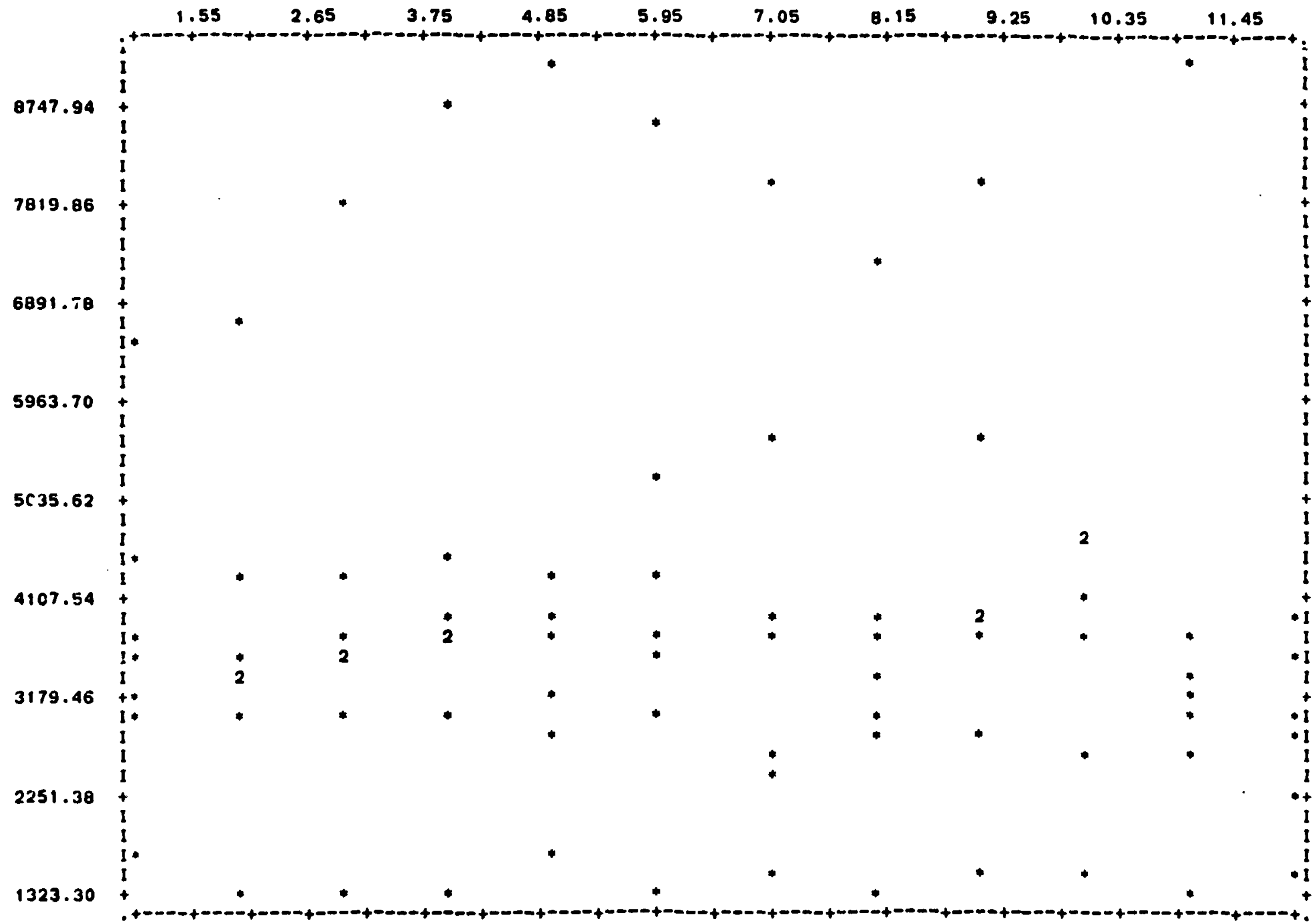
H With OMA (TOT Cost)--CPFF Contracts



H With OMA (TOT Cost)--CPIF Contracts



H With OMA (TOT Cost)--CPAF Contracts



Plot of H Over Time (TOT Cost)

APPENDIX B

ADDITIONAL TESTS FOR NORMALITY

CPFF

- - - - - RUNS TEST

H TOTAL

CASES	TEST VALUE	RUNS	LT	GE
36	3778.6000	24	18	18

Z	2-TAILED P
1.5219	.1280

- - - - - KOLMOGOROV - SMIRNOV GOODNESS OF FIT TEST

TOTAL

TEST DIST - NORMAL (MEAN = 4564.1583
STD. DEV. = 2989.8489)

CASES	MAX(ABS DIFF)	MAX(+DIFF)	MAX(-DIFF)
36	.2175	.2175	-.1392

K-S Z	2-TAILED P
1.305	.006

CPIF

```
- - - - - - RUNS TEST

     H          TOTAL

        CASES        TEST VALUE        RUNS       LT        GE
           24        3175.5000           20       12        12

          Z          2-TAILED P
        2.7133           .0057

- - - - - - KOLMOGOROV - SMIRNOV GOODNESS OF FIT TEST

     H          TOTAL

TEST. DIST. - NORMAL (MEAN =  3594.5833
STD. DEV. =   873.2093)

        CASES      MAX(ABS DIFF)   MAX(+ DIFF)     MAX(- DIFF)
           24          .2082           .2082           -.1246

        K-S Z      2-TAILED P
        1.020          .249
```

CPAF

- - - - - - RUNS TEST

H TOTAL

CASES	TEST VALUE	RUNS	LT	GE
24	3744.7000	8	12	12

Z	2-TAILED P
-1.8774	.0603

- - - - - - KOLMOGOROV - SMIRNOV GOODNESS OF FIT TEST

H TOTAL

TEST. DIST. - NORMAL (MEAN = 3776.4500
STD. DEV. = 704.3276)

CASES	MAX(ABS DIFF)	MAX(+ DIFF)	MAX(- DIFF)
24	.2134	.2134	-.0886

K-S Z	2-TAILED P
1.045	.225

CPFF--WHOLE SAMPLE

- - - - - RUNS TEST

H TOTAL

CASES	TEST VALUE	RUNS	LT	GE
720	232.6000	259	360	370

Z	2-TAILED P
-7.6079	.0000

- - - - - KOLMOGOROV - SMIRNOV GOODNESS OF FIT TEST

H TOTAL

TEST. DIST. - NORMAL (MEAN = 1040.3808
STD. DEV. = 2034.2828)

CASES	MAX(ABS DIFF)	MAX(+ DIFF)	MAX(- DIFF)
720	.3209	.3209	-.3017

K-S Z	2-TAILED P
8.610	0

CPIF--WHOLE SAMPLE

- - - - - RUNS TEST

H TOTAL

CASES	TEST VALUE	RUNS	LT	GE
480	203.4000	193	240	240

Z	2-TAILED P
-4.3864	.000

- - - - - KOLMOGOROV - SMIRNOV GOODNESS OF FIT TEST

H TOTAL

TEST. DIST. - NORMAL (MEAN = 1521.7246
STD. DEV. = 3348.0462)

CASES	MAX(ABS DIFF)	MAX(+ DIFF)	MAX(- DIFF)
480	.3438	.3438	-.3247

K-S Z	2-TAILED P
7.532	0

CPAF--WHOLE SAMPLE

- - - - - RUNS TEST

H TOTAL

CASES	TEST VALUE	RUNS	LT	GE
480	240.5500	165	240	240

Z	2-TAILED P
-6.9451	.0000

- - - - - KOLMOGOROV - SMIRNOV GOODNESS OF FIT TEST

H TOTAL

TEST. DIST. - NORMAL (MEAN = 1205.4794
STD. DEV. = 2334.2530)

CASES	MAX(ABS DIFF)	MAX(+ DIFF)	MAX(- DIFF)
480	.3684	.3694	-.2924

K-S Z	2-TAILED P
8.094	0

TEST WHOLE SAMPLE

- - - - - - RUNS TEST

H TOTAL

CASES	TEST VALUE	RUNS	LT	GE
1680	230.3000	525	840	840

Z	2-TAILED P
-15.4238	0

- - - - - - KOLMOGOROV - SMIRNOV GOODNESS OF FIT TEST

H TOTAL

TEST. DIST. - NORMAL (MEAN = 1225.0786
STD. DEV. = 2552.1148)

CASES	MAX(ABS DIFF)	MAX(+ DIFF)	MAX(- DIFF)
1680	.3275	.3275	-.3121

K-S Z	2-TAILED P
13.422	0

APPENDIX C

KENDALL CORRELATION COEFFICIENTS

---------- KENDALL CORRELATION COEFFICIENTS ---

VARIABLE PAIR		VARIABLE PAIR		VARIABLE PAIR		VARIABLE PAIR		VARIABLE PAIR	
A	.2140	A	.2863	A	.3114	A	.0993	A	.2007
WITH	N(84)	WITH	N(84)	WITH	N(84)	WITH	N(84)	WITH	N(84)
B	SIG .004	C	SIG .001	D	SIG .001	E	SIG .182	F	SIG .007
B	.2324	B	.4095	B	.1027	B	-.0307	B	.5381
WITH	N(84)	WITH	N(84)	WITH	N(84)	WITH	N(84)	WITH	N(84)
C	SIG .002	D	SIG .001	E	SIG .167	F	SIG .680	H	SIG .001
C	.2473	C	.1599	C	.5743	D	.3234	D	.2384
WITH	N(84)	WITH	N(84)	WITH	N(84)	WITH	N(84)	WITH	N(84)
E	SIG .001	F	SIG .032	H	SIG .001	E	SIG .001	F	SIG .002
E	.6623	E	.3333	F	.2127	C	.5042		
WITH	N(84)	WITH	N(84)	WITH	N(84)	WITH	N(84)		
F	SIG .001	H	SIG .001	H	SIG .005	D	SIG .001		
A	.1394	A	.4951	B	.0602	B	.5881	C	.2301
WITH	N(84)	WITH	N(84)	WITH	N(84)	WITH	N(84)	WITH	N(84)
OMA	SIG .061	H	SIG .001	OMA	SIG .418	H	SIG .001	OMA	SIG .002
D	.3074	D	.5203	H	.3058	C	.5743		
WITH	N(84)	WITH	N(84)	WITH	N(84)	WITH	N(84)		
OMA	SIG .001	H	SIG .001	OMA	SIG .001	H	SIG .001		
PROD	.2387	PROD	.1079	PROD	.6150	NONPROD	.2587	NONPROD	.6133
WITH	N(84)	WITH	N(84)	WITH	N(84)	WITH	N(84)	WITH	N(84)
NONPROD	SIG .002	OMA	SIG .147	H	SIG .001	OMA	SIG .001	H	SIG .001

A VALUE OF 99.0000 IS PRINTED IF A COEFFICIENT CANNOT BE COMPUTED.

Total Contractor Cost--All Contracts

KENDALL CORRELATION COEFFICIENTS

VARIABLE PAIR		VARIABLE PAIR		VARIABLE PAIR		VARIABLE PAIR		VARIABLE PAIR	
A WITH B	.7238 N(36) SIG .001	A WITH C	.7397 N(36) SIG .001	A WITH D	.5270 N(36) SIG .001	A WITH E	.1873 N(36) SIG .108	A WITH F	.1270 N(36) SIG .276
B WITH C	.6413 N(36) SIG .001	B WITH D	.5873 N(36) SIG .001	B WITH E	.2540 N(36) SIG .030	B WITH F	.2254 N(36) SIG .054	B WITH H	.8635 N(36) SIG .001
C WITH E	.1810 N(36) SIG .121	C WITH F	.0952 N(36) SIG .414	C WITH H	.7524 N(36) SIG .001	D WITH E	.4127 N(36) SIG .001	D WITH F	.4476 N(36) SIG .001
E WITH F	.7302 N(36) SIG .001	E WITH H	.2127 N(36) SIG .068	F WITH H	.1460 N(36) SIG .211	C WITH D	.5333 N(36) SIG .001	D WITH H	.5905 N(36) SIG .001
A WITH OMA	.1683 N(36) SIG .149	B WITH OMA	.2413 N(36) SIG .039	C WITH OMA	.1746 N(36) SIG .135	D WITH OMA	.4190 N(36) SIG .001	H WITH OMA	.1937 N(36) SIG .097
PROD WITH NONPROD	.7333 N(36) SIG .001	PROD WITH OMA	.1524 N(36) SIG .192	PROD WITH H	.9270 N(36) SIG .001	NONPROD WITH OMA	.1841 N(36) SIG .115	NONPROD WITH H	.7683 N(36) SIG .001
								A WITH H	.8476 N(36) SIG .001

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Total Contractor Cost--CPFF Contract

KENDALL CORRELATION COEFFICIENTS

VARIABLE PAIR		VARIABLE PAIR		VARIABLE PAIR		VARIABLE PAIR		VARIABLE PAIR	
A WITH B	.2464 N(24) SIG .092	A WITH C	-.1739 N(24) SIG .234	A WITH D	-.2432 N(24) SIG .096	A WITH E	-.0725 N(24) SIG .620	A WITH F	-.0725 N(24) SIG .620
B WITH C	.1304 N(24) SIG .372	B WITH D	.2722 N(24) SIG .063	B WITH E	.1449 N(24) SIG .322	B WITH F	.1739 N(24) SIG .234	B WITH H	.4348 N(24) SIG .003
C WITH E	.5652 N(24) SIG .001	C WITH F	.5362 N(24) SIG .001	C WITH H	.5797 N(24) SIG .001	D WITH E	.4900 N(24) SIG .001	D WITH F	.5336 N(24) SIG .001
E WITH F	.8696 N(24) SIG .001	E WITH H	.5072 N(24) SIG .001	F WITH H	.4928 N(24) SIG .001	C WITH D	.6280 N(24) SIG .001	D WITH H	.5408 N(24) SIG .001
A WITH OMA	-.0942 N(24) SIG .519	B WITH OMA	.1667 N(24) SIG .254	C WITH OMA	.5580 N(24) SIG .001	D WITH OMA	.5263 N(24) SIG .001	H WITH OMA	.4855 N(24) SIG .001
PROD WITH NONPROD	-.1449 N(24) SIG .322	PROD WITH OMA	-.0290 N(24) SIG .843	PROD WITH H	.2971 N(24) SIG .042	NONPROD WITH OMA	.5652 N(24) SIG .001	NONPROD WITH H	.5560 N(24) SIG .001
								A WITH H	.1739 N(24) SIG .234

A VALUE OF 99.0000 IS PRINTED IF A COEFFICIENT CANNOT BE COMPUTED.

Total Contractor Cost--CPIF Contract

KENDALL CORRELATION COEFFICIENTS

VARIABLE PAIR		VARIABLE PAIR		VARIABLE PAIR		VARIABLE PAIR		VARIABLE PAIR	
A WITH B	-.1522 N(24) SIG .298	A WITH C	-.1957 N(24) SIG .181	A WITH D	.4638 N(24) SIG .002	A WITH E	.3478 N(24) SIG .018	A WITH F	.4682 N(24) SIG .002
B WITH C	.0230 N(24) SIG .843	B WITH D	-.2246 N(24) SIG .125	B WITH E	-.3551 N(24) SIG .016	B WITH F	-.3230 N(24) SIG .027	B WITH H	.1159 N(24) SIG .428
C WITH E	.0362 N(24) SIG .805	C WITH F	-.1270 N(24) SIG .385	C WITH H	.4348 N(24) SIG .003	D WITH E	.5072 N(24) SIG .001	D WITH F	.5481 N(24) SIG .001
E WITH F	.6788 N(24) SIG .001	E WITH H	.3406 N(24) SIG .020	F WITH H	.2868 N(24) SIG .050	C WITH D	-.0362 N(24) SIG .805	D WITH H	.2391 N(24) SIG .102
A WITH OMA	.4058 N(24) SIG .006	B WITH OMA	-.3551 N(24) SIG .016	C WITH OMA	-.0072 N(24) SIG .961	D WITH OMA	.5797 N(24) SIG .001	H WITH OMA	.3406 N(24) SIG .020
PROD WITH NONPROD	-.1522 N(24) SIG .298	PROD WITH OMA	.2536 N(24) SIG .083	PROD WITH H	.3768 N(24) SIG .010	NONPROD WITH OMA	.0145 N(24) SIG .921	NONPROD WITH H	.4565 N(24) SIG .002
								A WITH H	.2681 N(24) SIG .067

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Total Contractor Cost--CPAF Contract

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